Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1954

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Rolling 30" ingots into Slabs on a Mesta 45"x90" Universal Reversing Slabbing Mill

Designed and Built by MESTA

SLABBING MILL

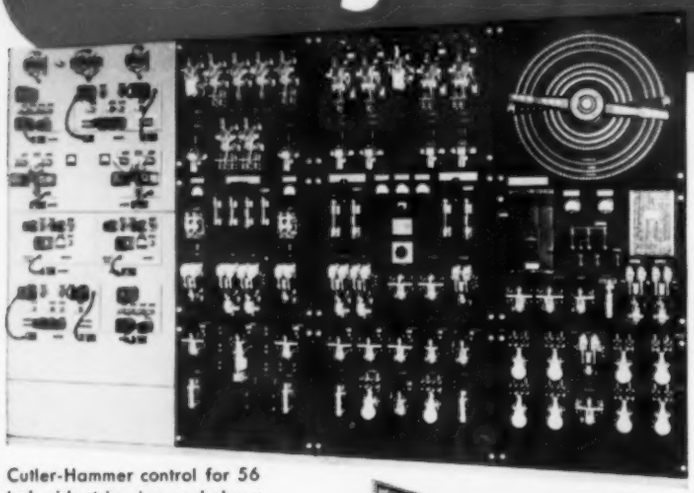
for GREAT LAKES STEEL CORPORATION DIVISION OF NATIONAL STEEL CORPORATION

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

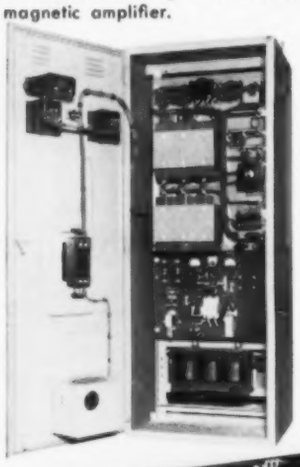
PITTSBURGH, PENNSYLVANIA

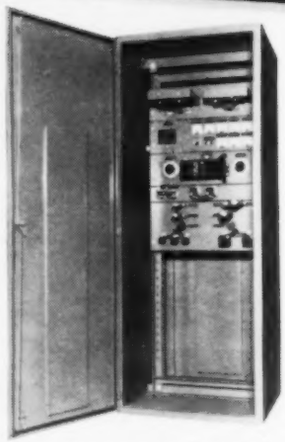
Nothing succeeds like success!



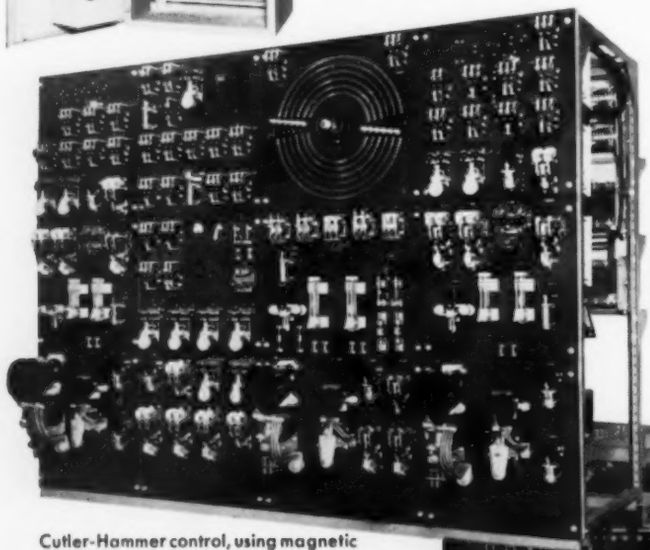
Cutler-Hammer control for 56 inch side trimming and shear line using magnetic amplifier.

Cutler-Hammer high frequency control for electric welding tube mill, using magnetic amplifier.

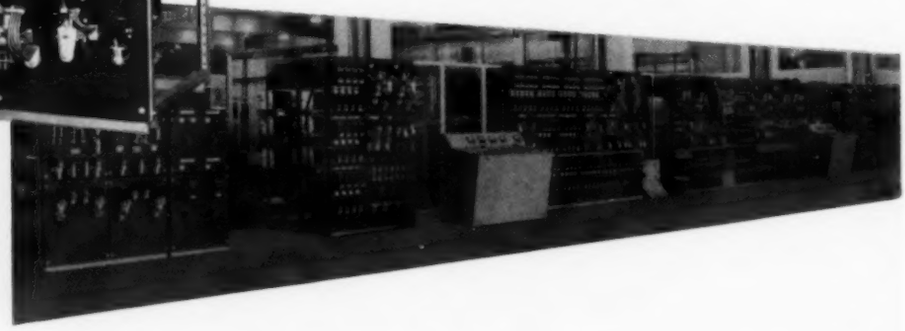




Cutler-Hammer magnetic amplifier speed regulator for a large tube mill.



Cutler-Hammer control, using magnetic amplifier, for reversing cold strip mill with tension and voltage regulation.



Cutler-Hammer D-C Controllers using magnetic amplifier for pipe mill in a southwestern steel mill.

Cutler-Hammer's experience in applying the Magnetic Amplifier to steel mill control assures correct solution of your problems.

Cutler-Hammer has been so successful in the past in applying the magnetic amplifier to steel mill control schemes, it is very natural that companies looking for best results should come to Cutler-Hammer.

This further adds to Cutler-Hammer's backlog of experience, and gives more positive assurance that the control scheme will properly apply and utilize all the inherent advantages of this dependable control component that has no moving parts, is capable of split-second response and many amazing features. . . . Nothing succeeds like success! CUTLER-HAMMER, Inc., 1269 W. St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER: published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 31, No. 8

TIN SHEARING LINE . . . Receives coils (up to 36,000 pounds) from Temper Mill. Material is side trimmed, sheared to specified lengths and classified into primes and seconds . . . all automatically. This Aetna-built line in the Fairless Works of U. S. Steel has a rated speed of 1250 f.p.m. for regular tin plate gauges in sheet sizes up to 38" x 43".

Tin Shearing Line built by Aetna-Standard for Fairless Works, U. S. Steel.

Flat-Rolled Equipment

SHEARING AND CLASSIFYING • SCRUBBING AND DRYING • RECOILING • SLITTING AND SIDE TRIMMING • ROLLER LEVELERS • PAY-OFF AND TENSION REELS • SIDE TRIM AND RECOIL • SIDE TRIM AND SHEAR • TIN PLATE, SIDE TRIM AND SHEAR • CLASSIFYING

SIDE TRIMMING AND RECOILING LINE . . . This 40" line prepares coils for the Electrolytic Tinning Line of Fairless Works, U. S. Steel. The strip (in coil form) is side trimmed at speeds up to 4000 f.p.m. The line operates under tension with ends of coils joined by seam welding. Close tolerance and high speeds are essential to the successful operation of the line.

40" Side Trimming and Recoiling Line in Fairless Works of U. S. Steel.

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

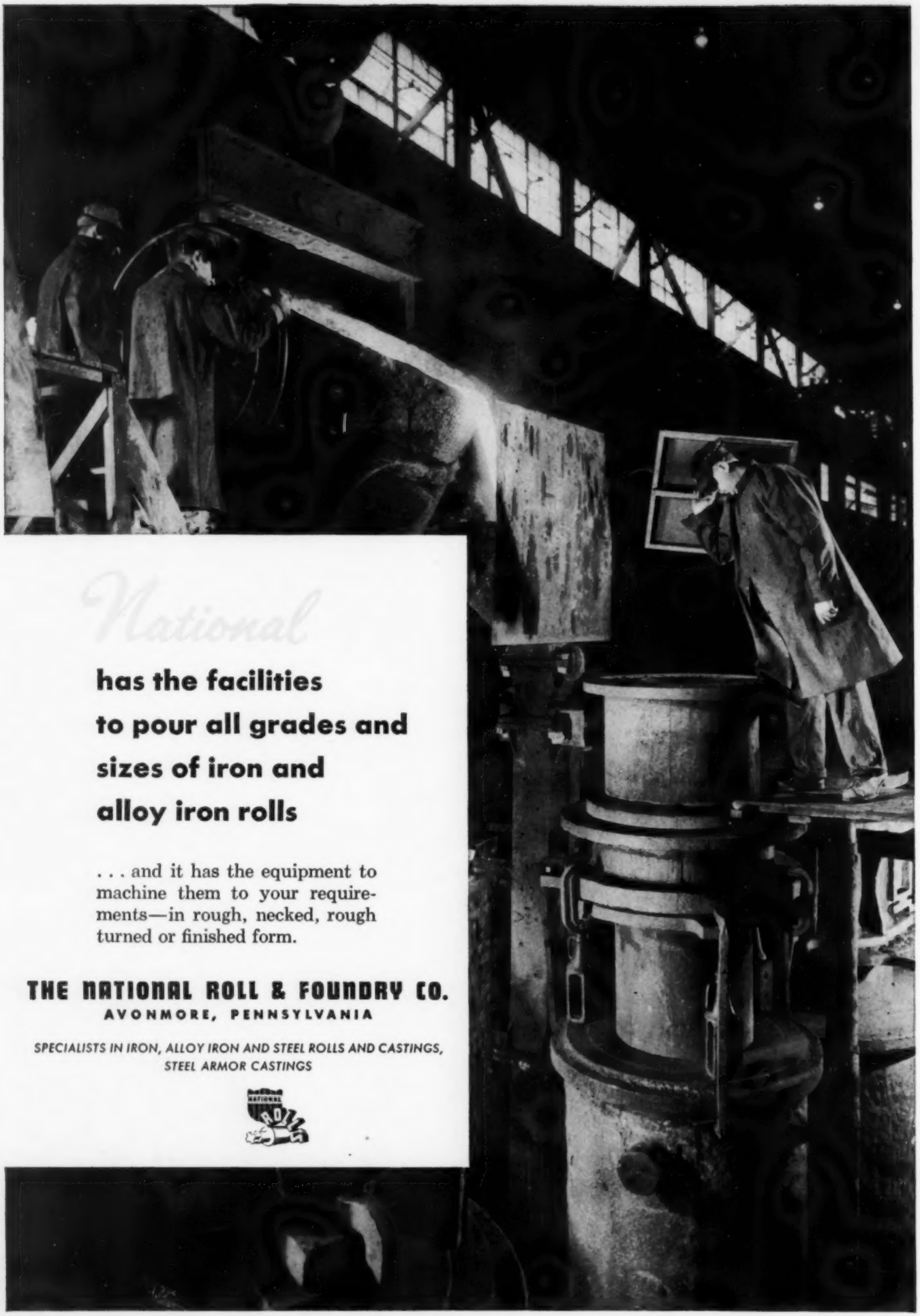
PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries



National

has the facilities to pour all grades and sizes of iron and alloy iron rolls

. . . and it has the equipment to machine them to your requirements—in rough, necked, rough turned or finished form.

THE NATIONAL ROLL & FOUNDRY CO.
AVONMORE, PENNSYLVANIA

SPECIALISTS IN IRON, ALLOY IRON AND STEEL ROLLS AND CASTINGS, STEEL ARMOR CASTINGS

CHANDEYSSON ELECTRIC COMPANY

4078 Bingham Avenue — St. Louis, Missouri

GOLDEN JUBILEE 1904 Chandeysson 1954

MEMO

TO YOU...Our Customers

WHAT'S HAPPENING AT CHANDEYSSON?

What has made Chandeysson the talk of the industry? Here are the answers as we see them—simply this...

In a progressive, virile program, launched a couple of years ago, these important decisions were made:

- To build an organization for expansion.
- To acquire more and better facilities, tools.
- To strengthen marketing policy and methods.
- To establish even higher standards of quality and service.
- To tell the advantages of generators for power conversion—particularly Chandeysson.
- To continue with products of integrity... a heritage that has earned respect and attention for fifty years.

TODAY...

...your enthusiastic response, proved by statistics and intangibles, justify these decisions. Chandeysson production is at an all-time high... more customers are buying Chandeysson products than ever before. Production meets your delivery requirements... you get more machine value per dollar than ever before. Our engineering development program assures better service now and in the future. A capable sales organization is at your service.

...and all at a reasonable profit in the spirit of American Free Enterprise. This milestone of successful operation is based on a half-century of fair dealing, quality products, progressive engineering and management.

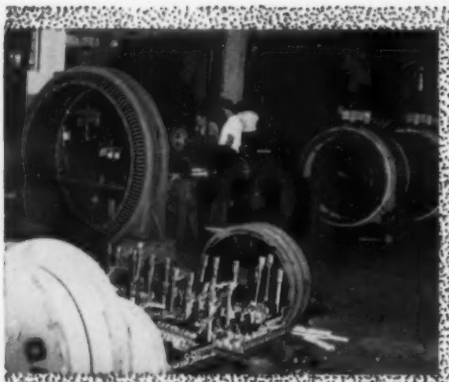
TOMORROW...

...you can discover for yourself

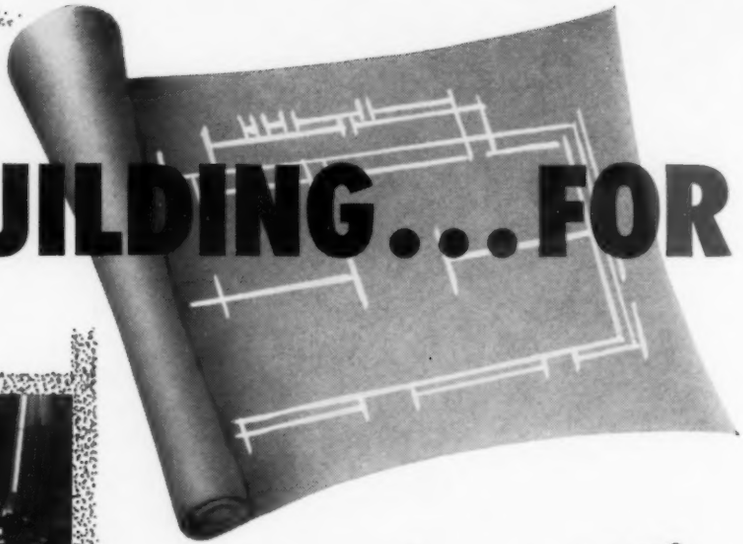
why Chandeysson is the standard of the industry...
why Chandeysson Generators are first choice of those who plan for years ahead...
why Chandeysson customers give us enthusiastic public endorsement...
how claims made can be backed up by the convincing proof of performance—now and for years to come.

James F Carland

Executive Vice-President
General Manager



BUILDING... FOR



Chandeysson

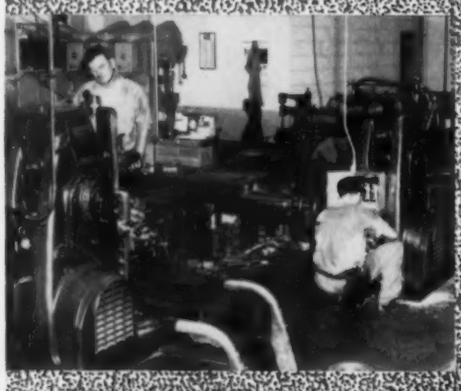
ELECTROLYTIC

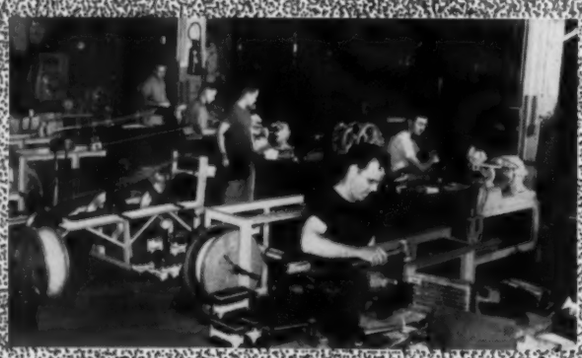
Lifetime power conversion

Perfection of detail made the first Chandeysson generators so successful that today, long years after, many are still in daily service.

We take pride in doing little things well—in precision machining an extra thousandth in a tolerance—being sure insulation is carefully and uniformly applied—fitting bearings with exactly the right clearance. Workers at Chandeysson have a creed of craftsmanship that carries through from selection of

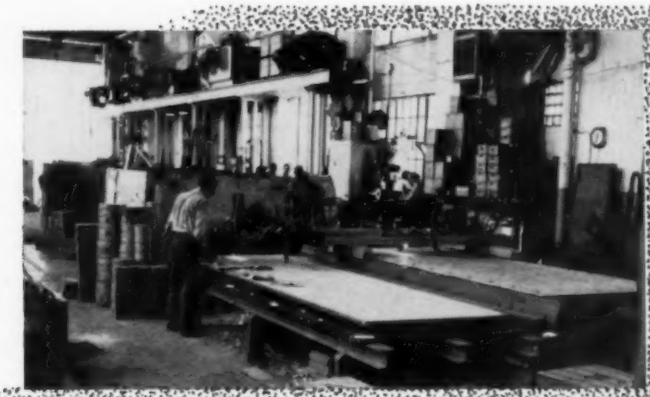
CHANDEYSSON





IN THIS MODERN, FAST-GROWING PLANT ***GENERATIONS OF***

THE *NEXT* FIFTY YEARS!



GENERATORS

. . . at low cost

raw materials to shipment of finished products. Every task is important—and every man.

Shown on this page are some of the men and some of the operations responsible for the high quality of Chandeysson products. We invite you to visit us and see for yourself the care and skill with which Chandeysson is building to meet your needs, not only for today but for generations to come.

ELECTRIC COMPANY

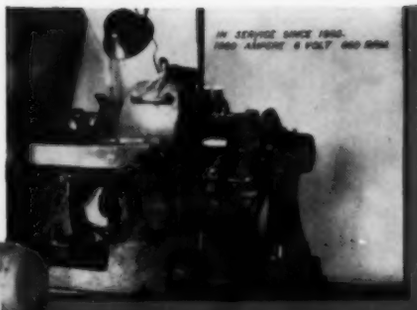
4076 Bingham Avenue • St. Louis, Missouri

GOLDEN 1904 Chandeysson 1954 JUBILEE

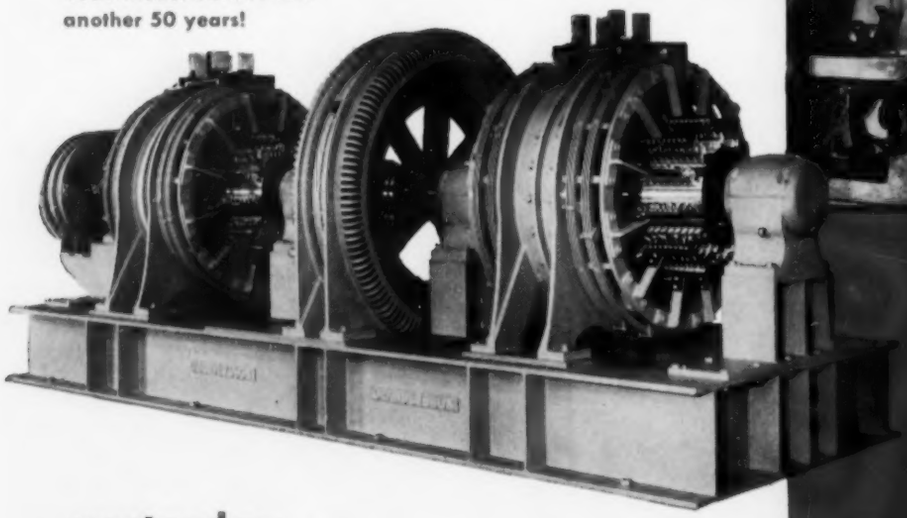
Factory views:
Chandeysson Electric Company,
Saint Louis, Missouri

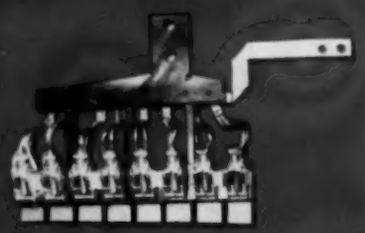
GOOD SERVICE ARE BUILT INTO EVERY Chandeysson GENERATOR

1904 Model
Still in daily service!



1954 Model Built to last
another 50 years!





yesterday...
today...
tomorrow...

Chandeysson

first name in fine

ELECTROLYTIC GENERATORS

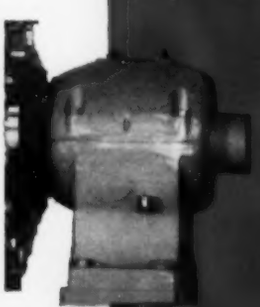
Every Chandeysson is built "from the ground up"—not assembled. Parts are specially designed, fabricated and integrated into each unit.

From this construction come three outstanding advantages to users:

1. **Built-in high power factor.**
2. **Sustained, lifetime overall efficiency as high as 85% that does not decrease with age or overload.**
3. **Overload capacity as great as 50% momentarily and 25% for long periods without distress.**

Yesterday, today, tomorrow . . . they're all the same to your Chandeysson generator. It keeps running . . . giving you lifetime dividends of highest quality performance, at lowest cost.

Bulletin D-102 contains data and specifications on Chandeysson machines. If you are interested in power savings and power dependability, it will pay you to read this bulletin. Your copy sent promptly, and without obligation.



Brush holder supports are of one piece bronze—precision machined, jig drilled and tapped for interchangeability and accurate positioning. Brush drag is balanced to eliminate skewing or vibration of brushes on the commutator.

Brush holders are accurately machined to assure snug fit that keeps them in place. Brush holders and spring assembly carry no current. Spring toggle arrangement assures uniform brush pressure throughout the life of the brush; yet permits open position to be held for brush inspection or replacement.

Collector ring assembly is same size as frame—with maximum access to brushes and commutator, for minor repair, inspection and maintenance in the coil and bus area. Open construction promotes cooling and reduces friction.

Sturdy, welded, stress relieved steel frames provide higher efficiency, greater strength and more flexible design.

Large size bearings (2½ to 1) assure long trouble-free life. Ample shaft diameter assures no flexing to overload any localized portion of the bearing—and maintains a sufficient air gap for stable operation.

CHANDEYSSON ELECTRIC COMPANY

4076 Bingham Avenue • St. Louis, Misso

GOLDEN
1904 Chandeysson 1954
JUBILEE

CONTINENTAL

SEMI-CONTINUOUS MERCHANT BAR MILL

When you plan additional rolling facilities—either a complete new installation or modernization of existing mills—consult with Continental. You will benefit from wide and varied experience in designing, building and erecting modern ferrous and non-ferrous mills. *For flat rolling:* slabbing, universal, plate, hot strip, cold strip and temper mills. *For shape rolling:* blooming, structural, rail, billet, rod and merchant mills.

Continental also builds a complete line of mill auxiliary equipment engineered to meet your exact requirements.

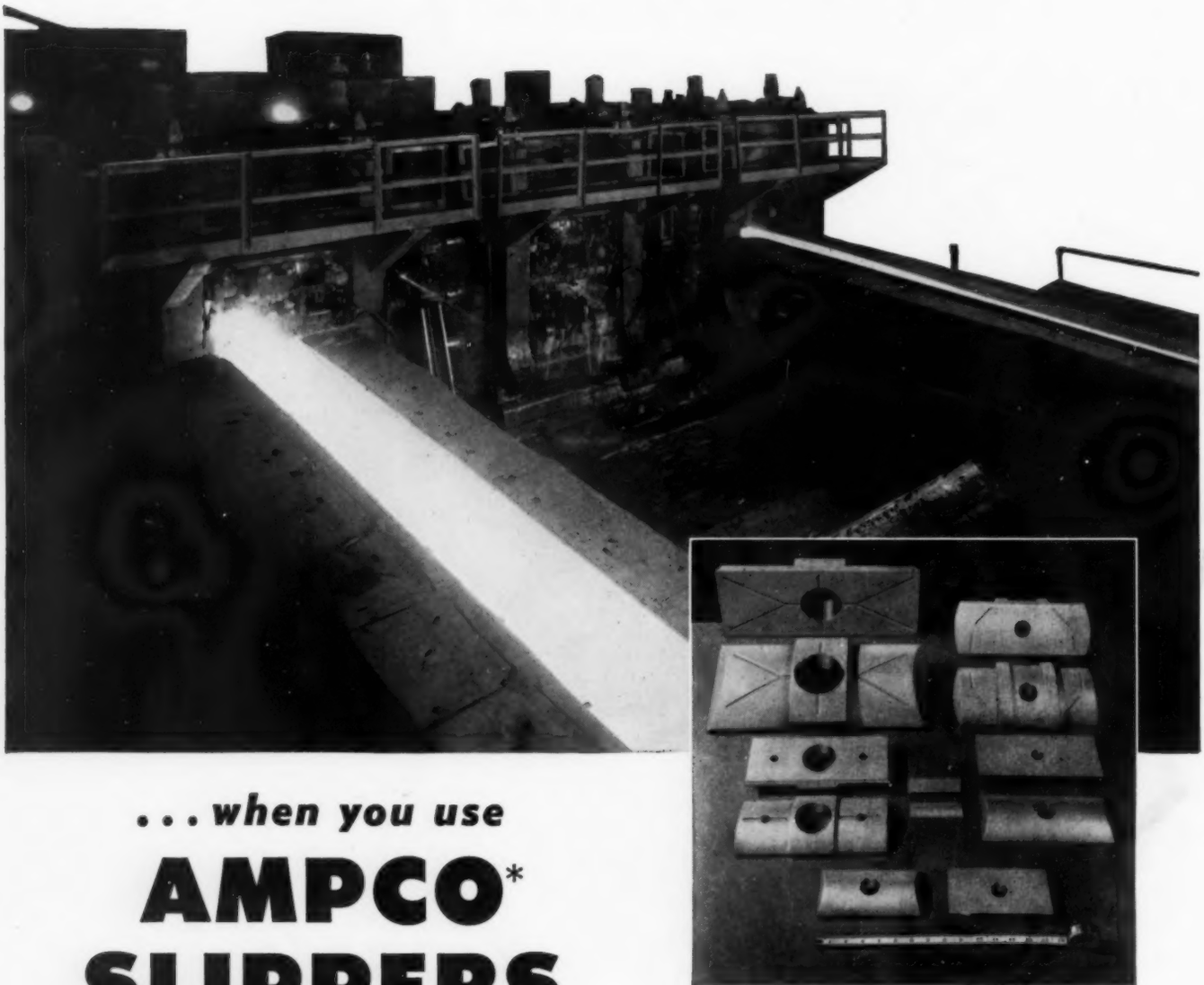
- COMPLETE ROLLING MILLS
- ROLLS • ROLL LATHES
- CONTINENTAL CHIPPER
- SPECIAL MACHINERY
- STEEL CASTINGS • WELDMENTS
- COPES-VULCAN BOILER CONTROLS AND CLEANING

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

CHICAGO · PITTSBURGH

CONTINENTAL
Foundry & Machine
Company

Production Steps Up Costs Step Down



. . . when you use

AMPCO* SLIPPERS

THERE'S plenty of "plus value" in slippers cast of Ampco Metal. They're tough — have unusual resistance to wear. They withstand the tremendous impacts and shock loads of steel-mill operation without squashing out. They have high fatigue strength.

These properties mean lower costs for you — less downtime — longer runs without replacement.

You get these slippers in the form you need to meet your specific operation. They're available "cast-to-size" or as rough castings. "Cast-to-size Slippers" come either with tolerances of minus 0, plus 1/32; or plus 0, minus 1/32. Oil grooves are cast in, if you want them.

And that's not all. Ampco Metal's stamina, toughness, and corrosion resistance mean that it's ideally suited for cutting costs in other steel-mill applications, too — screw-down nuts, wear plates, flash-welder dies, pickling equipment. Get the whole money-saving story from your nearby Ampco field engineer or write us direct

G-20

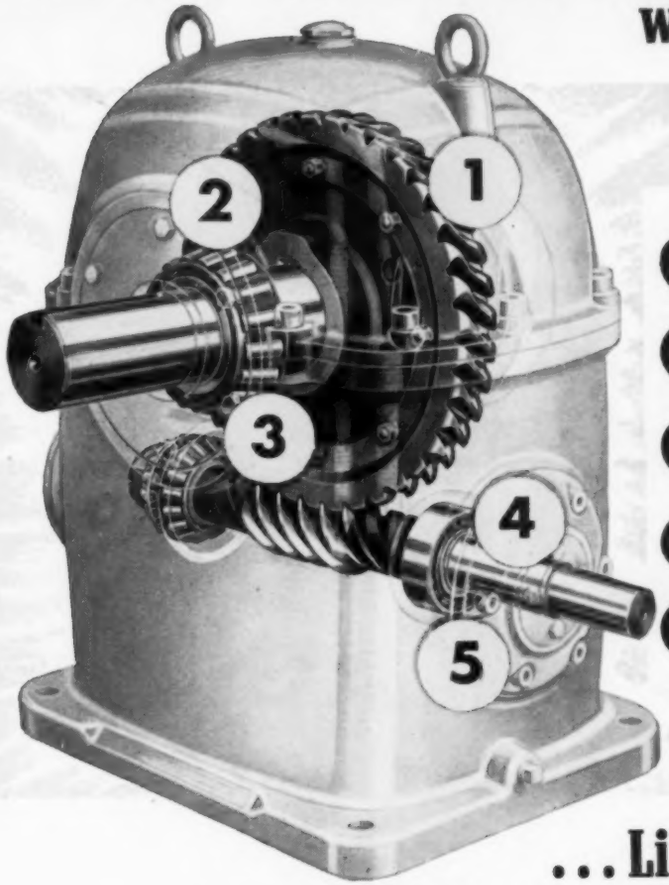
*Reg. U. S. Pat. Off.

AMPCO METAL, INC. AMPCO®

DEPT. IS-8, 1740 S. 38TH STREET
MILWAUKEE 46, WISCONSIN

West of the Rockies it's Ampco's Burbank Plant, Burbank, California

When your speed reduction job calls for high ratios with right-angle takeoff . . .



1. **NICKEL-BRONZE WORM GEARS,** chill cast in dry sand, combine low coefficient of friction with high tensile strength.
2. **HIGH-CAPACITY ROLLER BEARINGS** take both thrust and radial loads. Lower wear and friction losses reduce maintenance.
3. **ALL-SPEED EFFICIENCY** results from reduced sliding action between worm threads and gear teeth, plus smoother power delivery.
4. **ONE-PIECE FORGED SHAFTS** are alloy steel, carburized and heat-treated for great impact resistance.
5. **AUTOMATIC SPLASH LUBRICATION** reliably supplies oil to all bearings and gear teeth at all speeds.

. . . Link-Belt gives you

everything you want in WORM GEAR DRIVES

WITH their compact, high-strength design, Link-Belt Worm Gear Drives permit high-ratio speed reductions in small space. High input speeds and low output speeds are provided, with ample capacity for heavy loads.

Three basic types cover the complete field of application: Single worm gear drives, helical worm gear drives and double worm gear drives. All are available with either horizontal or vertical shafts, and single or double gear reductions for convenient and compact connection.

Link-Belt Worm Gear Drives are available in 3.1:1 to 8000:1 reduction ratios, 1400 to 123,000 in. lbs. torque—0.22 to 564 output shaft rpm. Ask for Book 2324-A.

LINK-BELT 13,402

ENCLOSED GEAR DRIVES

WHY PRE-INTEGRATED LINK-BELT DRIVES CUT YOUR POWER TRANSMISSION COSTS

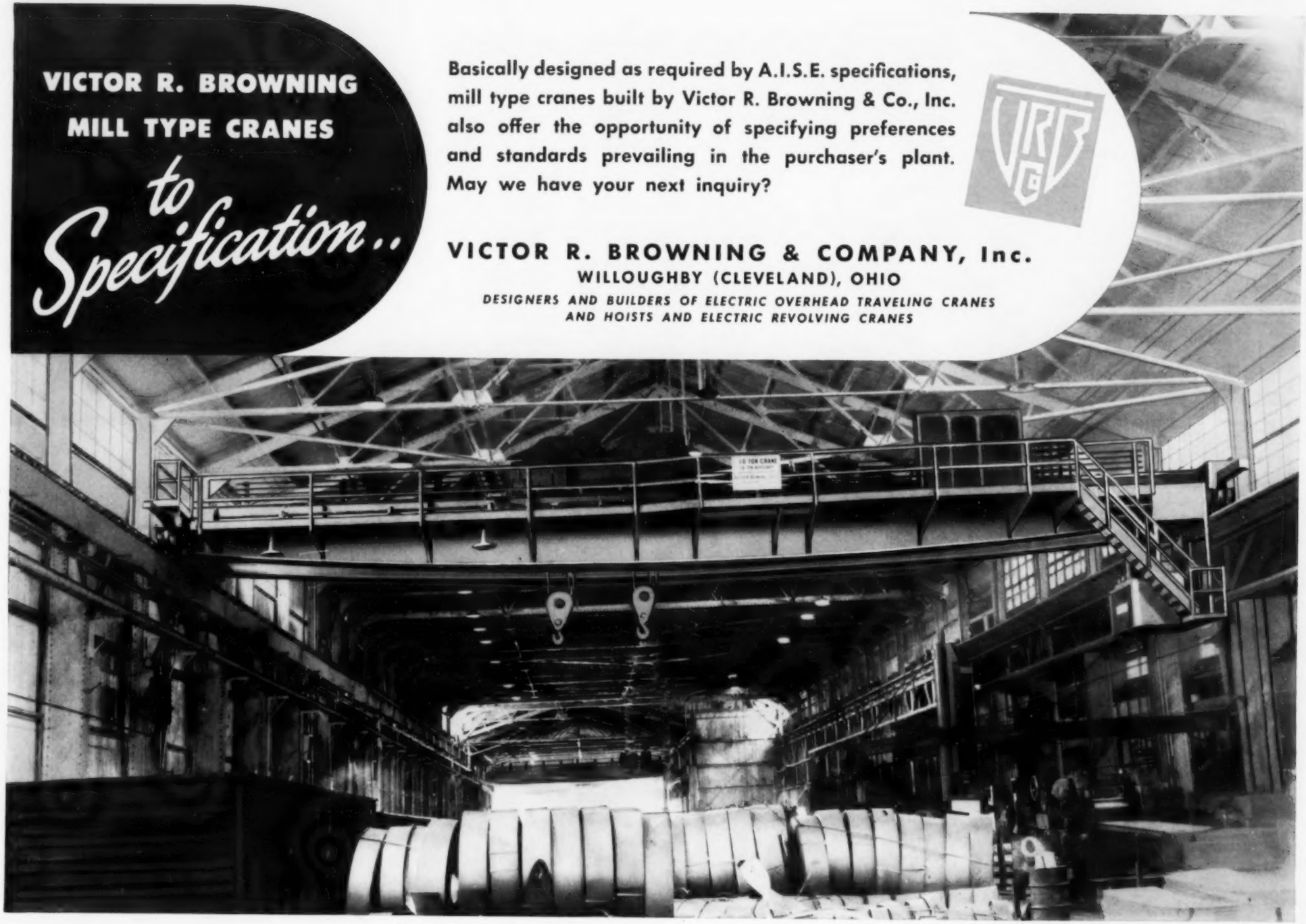
In addition to all three types of enclosed gear drives, Link-Belt builds variable speed drives, fluid drives—chains, sprockets, couplings, bearings, shafting, etc. All are pre-engineered for easy installation and maximum efficiency.

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

VICTOR R. BROWNING
MILL TYPE CRANES
to Specification..

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES



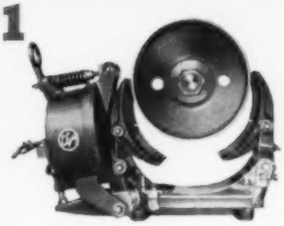
When Buying Electric Cranes

LET EC&M SUPPLY FULL COVERAGE

BRAKES · DISCONNECT SWITCHES
CONTROLLERS · LIMIT STOPS

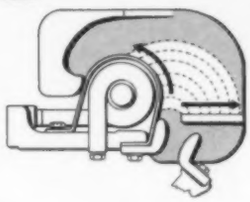
EC&M's Complete Line Includes—

1



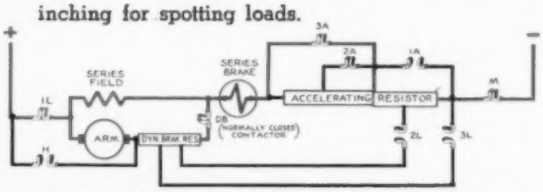
LONG-LIFE brakes for cranes operated by a-c or d-c power. . . Give high speed performance—with low upkeep.

2



Contactors operate on the LINE-ARC principle — no destructive burning of arc shields—cool contacts . . . reduced maintenance.

3 Simplified, Safe Dynamic Lowering Circuits for hoist motions respond quickly and permit accurate inching for spotting loads.



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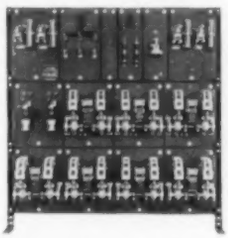


Reversing-plugging Control for bridge and trolley motions — automatically-controlled acceleration and only one adjustable relay for plugging.

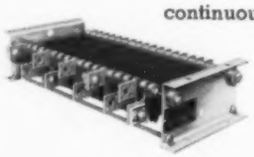
5

Youngstown Safety Limit Stops protect against overhoisting accidents—a positive check against human errors.

6

Cam-type Master Switches have narrow width and short throw—less fatiguing on the operator.

7 Tab-Weld Plate Resistors—spot-welding provides a continuous path, and keeps resistance value constant.



8

Manual-magnetic Disconnect Switches operate with ease—are arranged to control crane lights, too.

Put your crane control problems up to EC&M. Each job is accurately engineered to give fine performance. When buying cranes, specify EC&M for complete crane control.

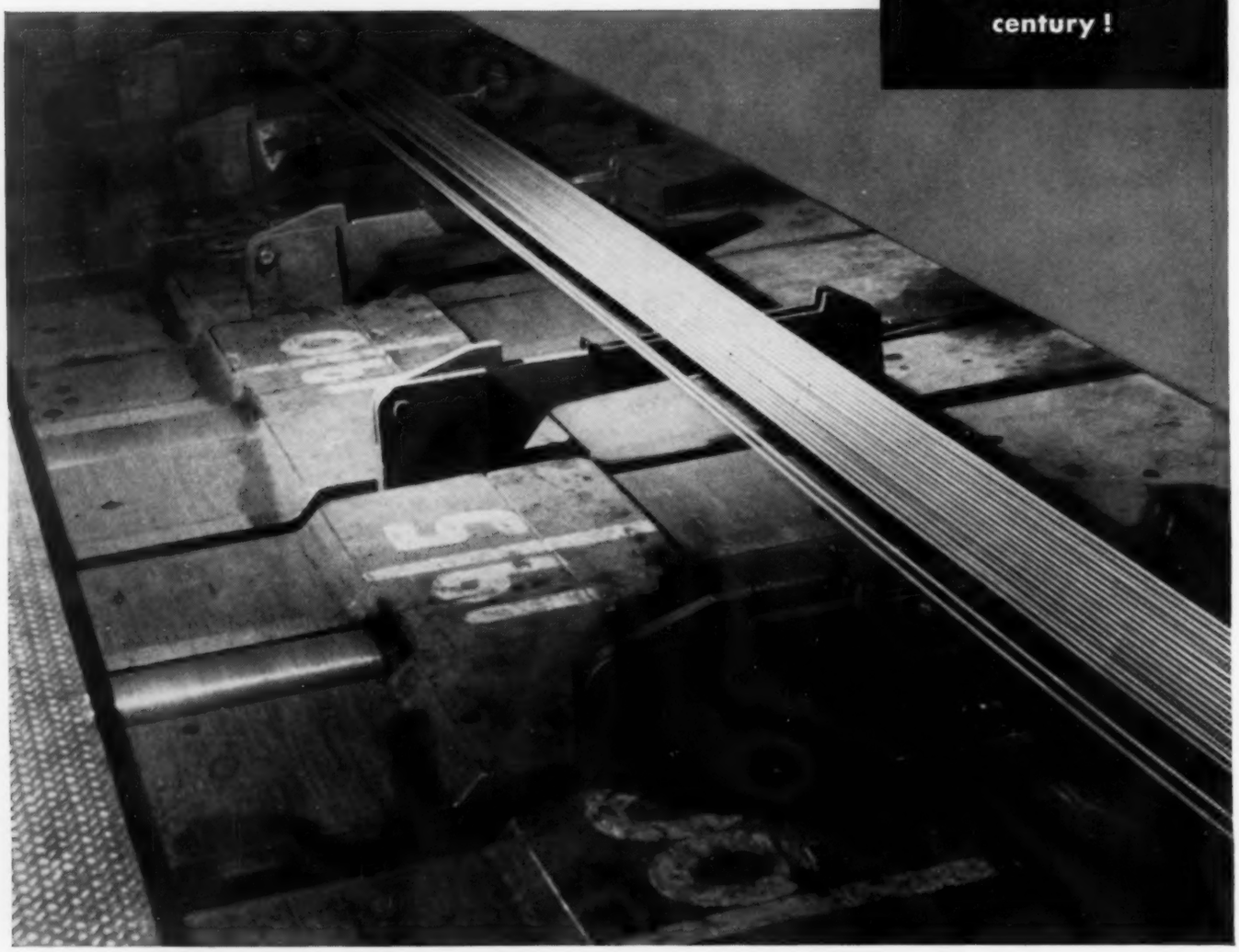
EC&M's Fiftieth Anniversary

THE ELECTRIC CONTROLLER & MANUFACTURING CO.

2499 E. 79th St. Cleveland 4, Ohio

for more automatic transfer and handling . . . look to **BIRDSBORO**

Designers and Builders of Better Steel Mill Machinery for over half a century !



Designers and Builders of:
STEEL MILL MACHINERY
HYDRAULIC PRESSES
CRUSHING MACHINERY
SPECIAL MACHINERY
STEEL CASTINGS
Weldments "CAST-WELD" Design
ROLLS: Steel, Alloy Iron, Alloy Steel

• Birdsboro-built Cooling Bed Shear Approach Table Transfer, showing shuffle bars, double shear approach table and transfer that feeds double cold bar shear simultaneously. Transfer passes lift of bars from shuffle bars to second table without interfering with bars on first table.

MM-34-54

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. Offices in Birdsboro, Pa. and Pittsburgh, Pa.

Maintenance Costs Go Down

with NATIONAL CARBON BRUSHES for

TRADE-MARK

MAIN DRIVE, MILL-TYPE AND GENERAL-PURPOSE MOTORS

ENGINEERS:

Fewer items do a better job when you select "National" brushes—simple, fast, accurate brush specification for *you!*

MAINTENANCE MEN:

Long life, low friction, minimum commutator maintenance — an outstanding cost-record for *you!*

PURCHASING AGENTS:

The brushes you want, *when* you want them, from stock or catalog listings — you get a higher degree of in-plant-standardization, lower inventory, fewer costly, short-run items!

STOREKEEPERS:

Stack 'em high, wide and handsome with these durable, easy-to-identify "National" brush cartons — good housekeeping, faster check-outs for *your* department!

How good is really good brush performance? Use "National" brushes and see!

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation

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NATIONAL STANDARDIZED BRUSHES

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BOILER COMBUSTION CONTROL SYSTEMS
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METALLURGICAL FURNACE CONTROL SYSTEMS
CONTROL SYSTEMS FOR AUTOMOTIVE AND
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HAGAN
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steel is made

RESULTS TELL THE STORY

Every advance toward higher combustion efficiency in the steel industry has demanded better automatic control and instrumentation. Hagan equipment and Hagan methods have always been in the lead in solving the problems and have contributed to the success of many new fuel-burning practices.

Hagan installations in the plants of the major steel producers indicate the diversity of the design, development and application problems solved by Hagan engineers.

Automatic Combustion Control for boilers has advanced from the simple systems for gas and stoker fired units to the complex systems required for simultaneous firing of several fuels in a single furnace. Hagan pioneered the automatic control systems for each successive step.

Similar advances have occurred in metallurgical furnace practice, with the added complexity of reversal of direction of firing and the operation of extremely heavy dampers. Furnace types using Hagan Automatic Control and Instrumentation include billet heating, single and multiple-zone slab heating, open hearth and blast furnaces, and soaking pits.

Gas mixing stations, based on measurement and calorific value or on volumetric ratios, are among the numerous applications where Hagan Automatic Control and Instrumentation have contributed to the effective use of waste fuels.

Among other diversified applications are: Measurement and control of air delivery from blast furnace blowers, with automatic compensation for barometric pressure and air temperature changes; automatic control and instrumentation for coke oven crossover mains, exhausters, stacks and underfiring; natural gas flow metering, with fully automatic pressure and temperature compensation; line type metering of liquid fuel for record and control; oxygen flow measurement and control.

Our staff of engineers will be pleased to consult with you on your automatic control and instrumentation problems.

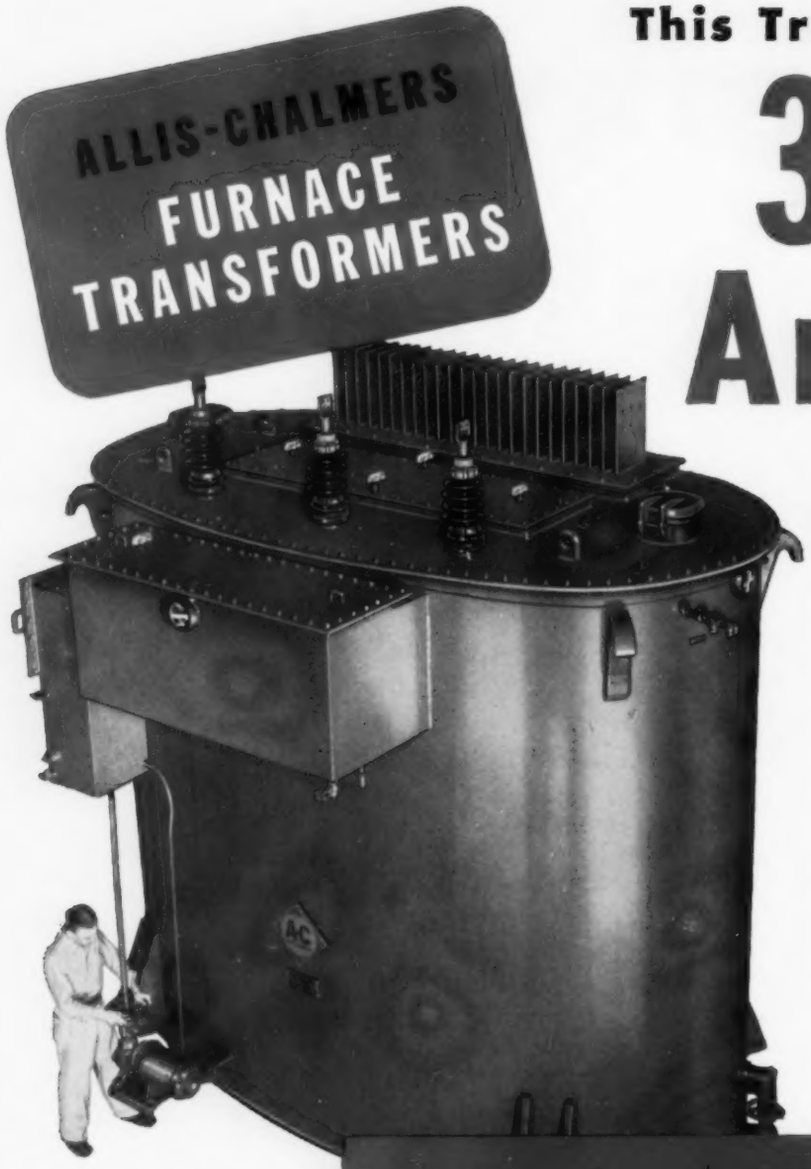
HAGAN CORPORATION

Hagan Building

Pittsburgh 30, Pennsylvania

This Transformer Delivers

33,962 Amperes

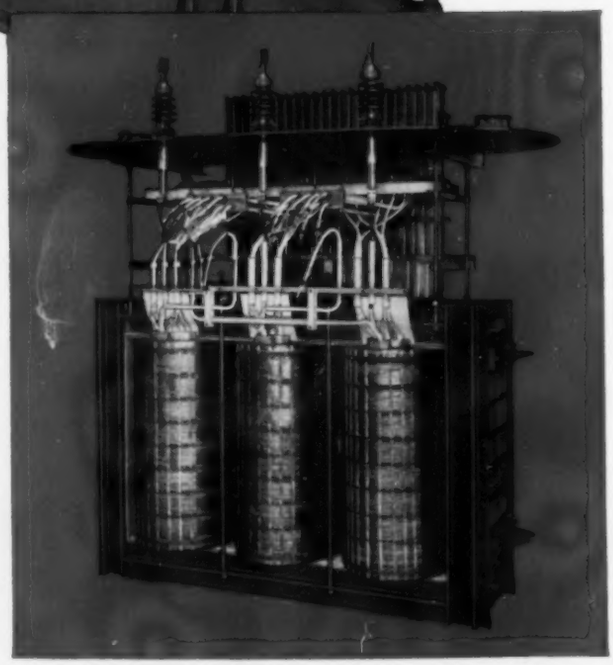


Providing high continuous current for specialized steel processing is an everyday duty for this transformer. Its well-balanced design and sturdy construction is based on past records of Allis-Chalmers transformers which show ability to withstand as much as 25 to 30 years of the repeated daily short circuits encountered in furnace operation. Allis-Chalmers has been building arc furnace transformers for over 45 years.

In addition to furnace transformers in any rating up to the largest demanded by the industry, Allis-Chalmers builds a complete line of arc furnace electrical equipment, including electrical control, circuit breakers, and auxiliary transformers.

Next time you consider a new or replacement arc furnace transformer, consult the Allis-Chalmers district office nearest you or write Allis-Chalmers, Milwaukee 1, Wis.

A-4318

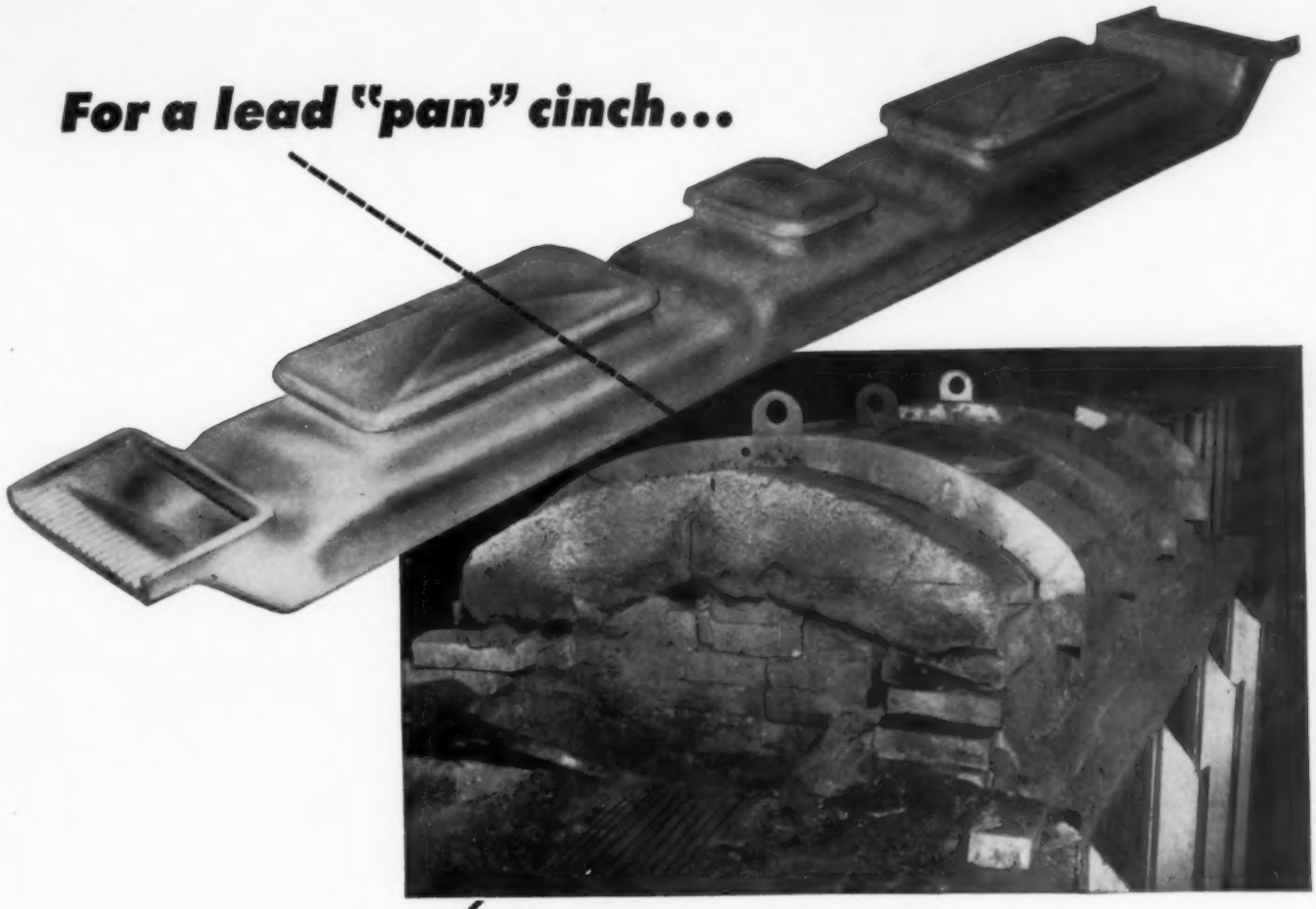


One of three 20,000-kva arc furnace transformers recently built by Allis-Chalmers for a large eastern steel manufacturer. Each can deliver a continuous current of 33,962 amperes per phase. Picture at right shows core and coil assembly.

- Extremely heavy supports brace coils against severe short circuit stresses.
- Skilful insulation techniques protect windings from overvoltages due to wide tap range. Some units are designed for as much as 50% range in secondary voltages.
- Tap-changing mechanism, specially designed for furnace transformers, is in separate compartment to facilitate periodic inspection and maintenance. Wide, flat contacts provide the long life needed for numerous daily tap-changing operations. Mechanism can be either motor driven or manually operated.
- Grit blasting and three coats of baked-on alkyd resinous paint give transformer good surface protection against industrial corrosion.

ALLIS-CHALMERS

For a lead "pan" cinch...



it's THERMALLOY* to outlast cast iron by 479 days!

A large steel and wire company uses a double-lead patenting furnace to give good drawing qualities to wire. In this process, wire is drawn through a "lead" pan enclosed in the furnace where temperatures range from 1600 to 1650°F.

Previously, cast iron "lead" pans were used . . . and the furnace had to shut down nearly every 21 days because the pan burned out and needed replacement. Then, a Thermalloy "lead" pan with integrally cast sinkers was installed. *To date, this pan has over 500 days of service* . . . saving this company expensive hours of repair and down time.

This is just one example of how a Thermalloy heat-resistant casting has helped a manufacturer to realize more economy in heat-treating parts. Do you have a similar need for Thermalloy in retorts, furnace parts, trays, racks, pots or muffles? Call in an Electro-Alloys engineer for full information, or write Electro-Alloys Division, 5006 Taylor Street, Elyria, Ohio.

THERMALLOY "LEAD" PAN ADVANTAGES

- Resists air-line attack, scaling and oxidation.
- Higher strength prevents sagging and distortion.
- Less weight means easier installation and less maintenance of supporting arches.
- Greater resistance to abrasion.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

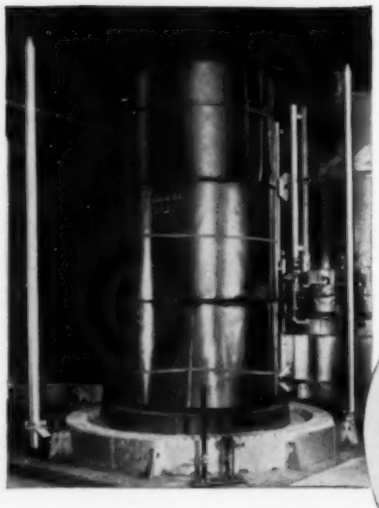
A *miracle* of Annealing Efficiency

Here's the fastest, most accurate annealing system yet developed . . . with a plus feature that *eliminates down time due to repair and maintenance.* Truly a miracle of annealing efficiency. That's the Lee Wilson Single-Stack Portable Base Radiant Tube Annealing System, the latest innovation by the company that invented and developed radiant tube annealing.

A Lee Wilson engineer can prove to you that by using single-stack type furnaces you are able to double production from a given floor area, and with lighter, less expensive auxiliary equipment. The new, doubly efficient, high speed Wilson "O" tube not only steps up production speeds but permits a much greater accuracy of heat control. This means you get faster production of a better product.

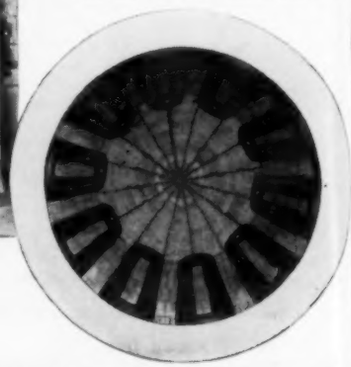
And the completely portable base can, when maintenance is required, be detached in a matter of minutes, removed by light crane equipment . . . a spare base dropped in place, and production continued.

There's a lot more . . . for example, expensive basements and understructures have all but been eliminated. But why not get the full story? Write today for a copy of Lee Wilson's Single-Stack Portable Base brochure.



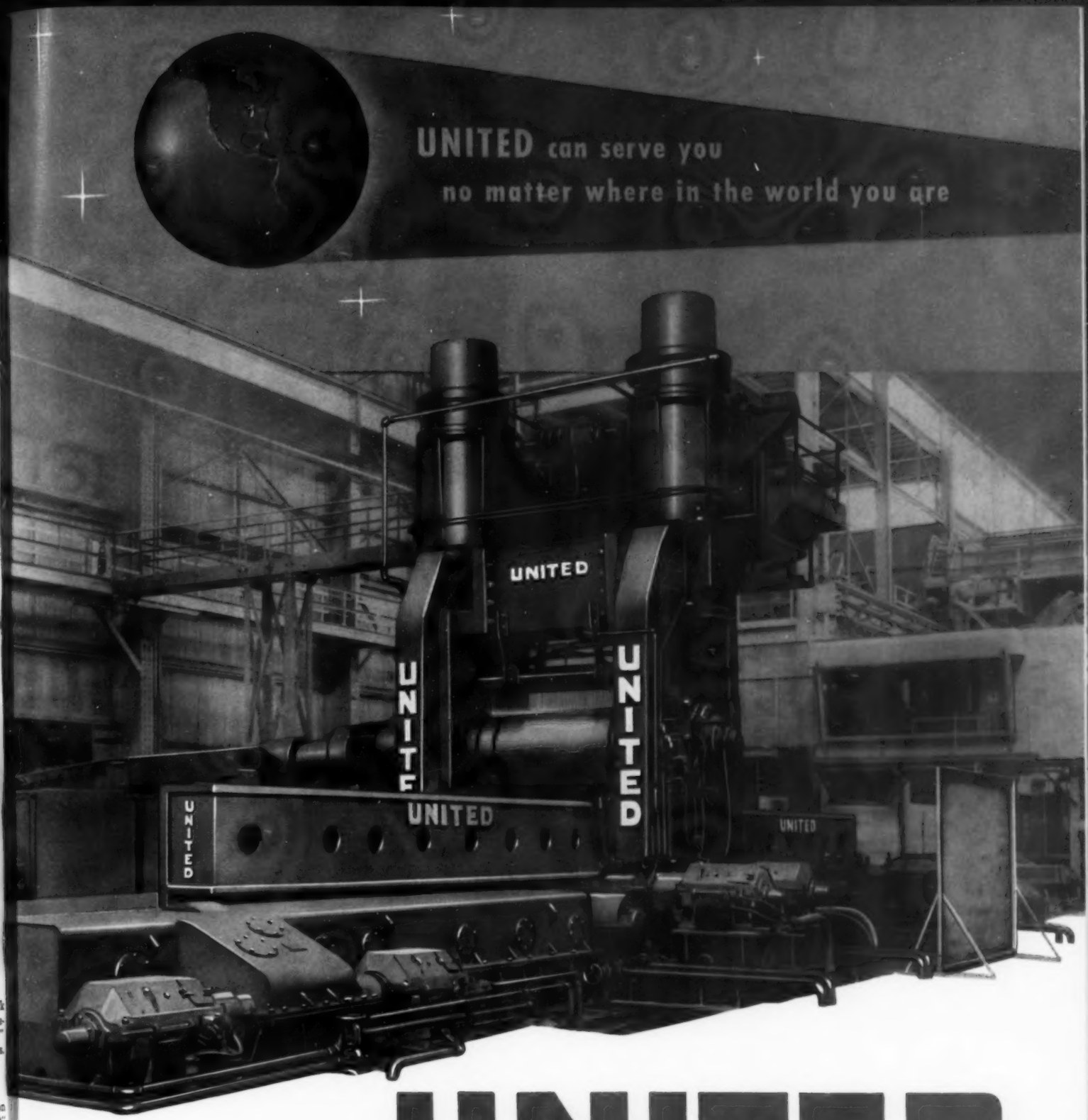
A typical load on a single-stack furnace base . . . 72" in diameter . . . a piling heighth of 156" . . . each coil weighing 20 tons.

The heart of the Lee Wilson Single-Stack Furnace is the "O" Type Radiant Tube arrangement that delivers an input of 500,000 BTU per tube, per hour.



Lee Wilson ENGINEERING COMPANY • INC.

20005 WEST LAKE ROAD • CLEVELAND, OHIO



UNITED®

Slabbing Mill

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

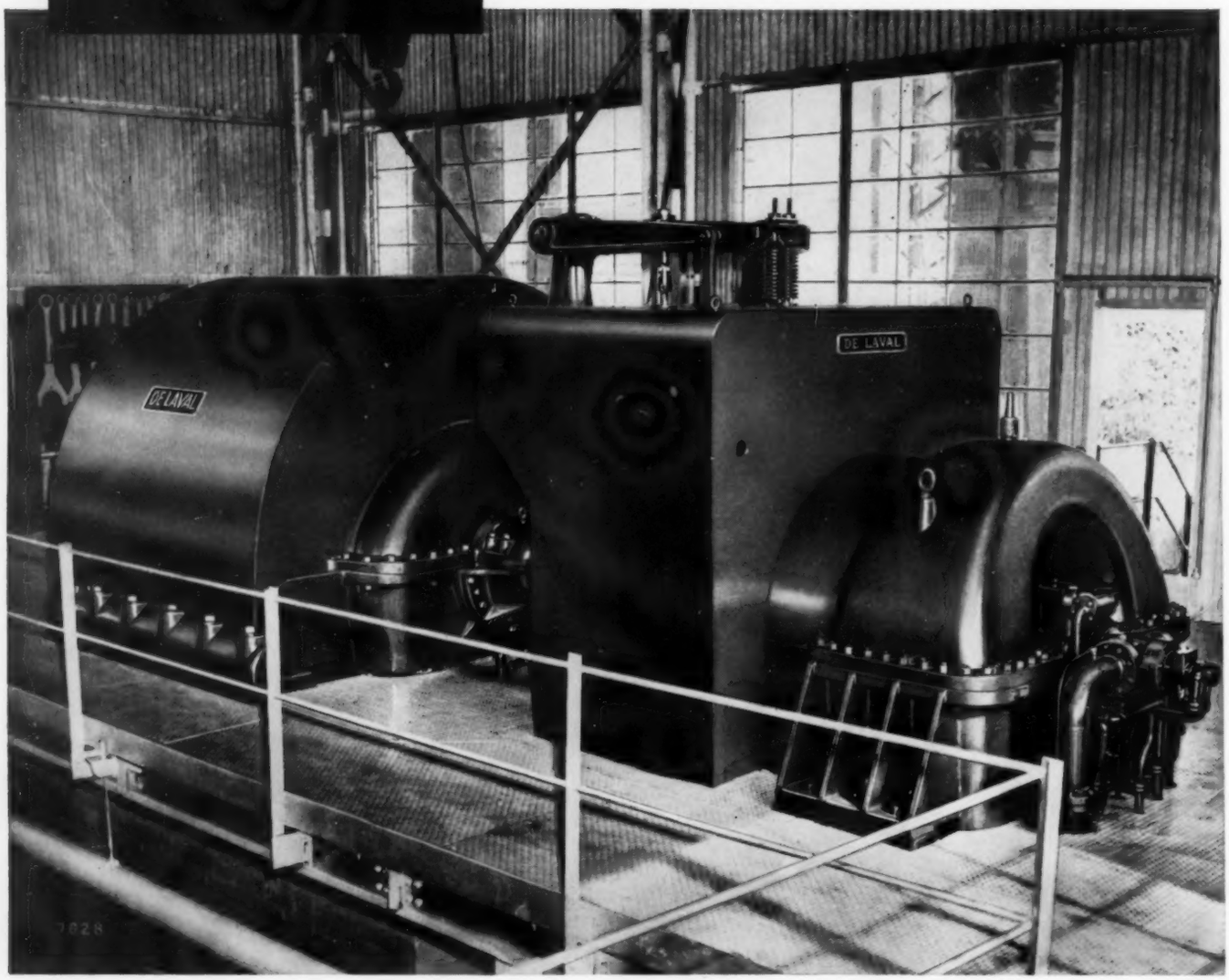
Plants at Pittsburgh • Vandergrift • New Castle • Youngstown • Canton

Subsidiaries: Adamson United Company, Akron, Ohio
Lobdell United Company, Wilmington, Delaware
Stedman Foundry and Machine Company, Inc., Aurora, Indiana

Designers and Builders of Ferrous and Non-Ferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

DE LAVAL CENTRIFUGAL BLOWER

delivers 75,000 cfm for southern steel mill



This De Laval 75,000 cfm blast furnace blower in a southern steel mill is driven by a 9,450 hp De Laval turbine operating at 2,900 rpm. Discharge pressure of the blower is 35 psig.

De Laval blowers have what it takes to give long service. The rugged casings and sturdy, perfectly balanced rotors are built to take punishment. The pressure lubricated sleeve bearings and Kingsbury type thrust bearing add durability and reduce maintenance. Both the turbine and blower are De Laval-designed and De Laval-made for top performance.

De Laval centrifugal blowers and compressors are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem. Consult your De Laval Sales Engineer.

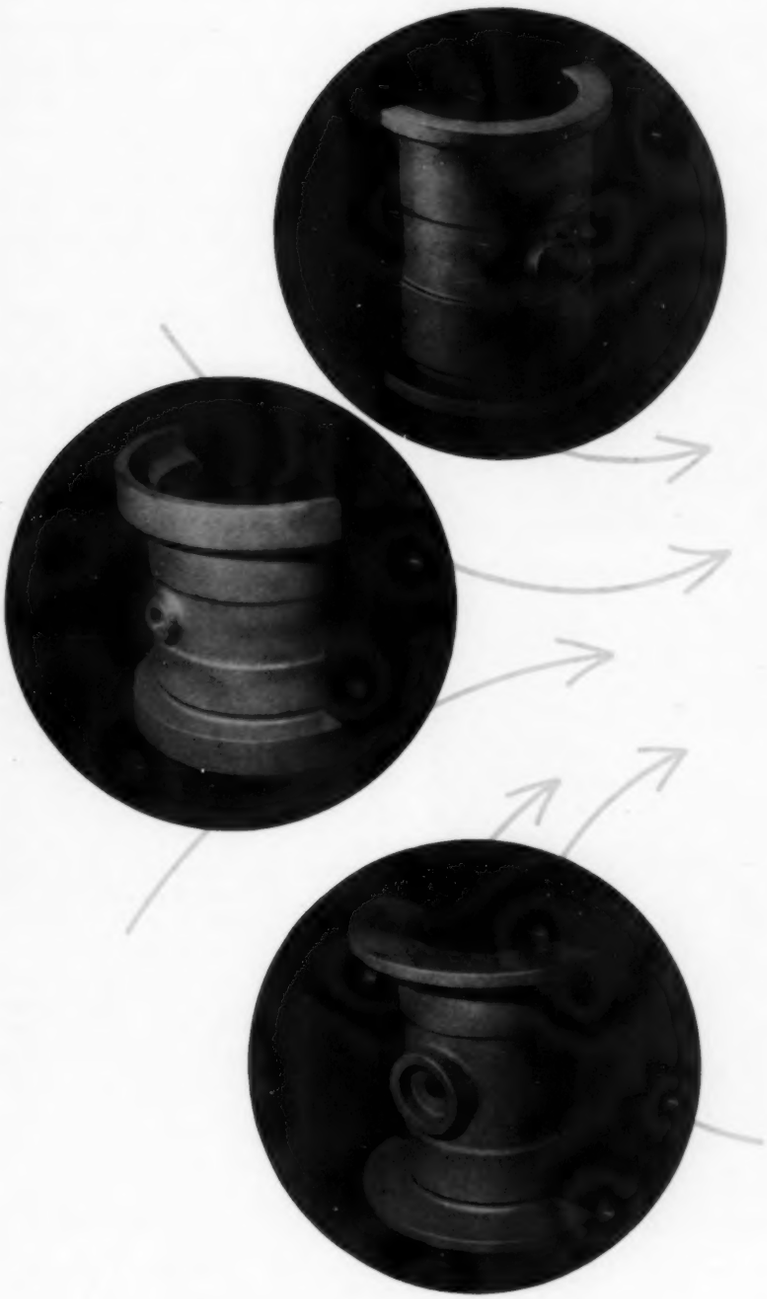
DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

870 Nottingham Way, Trenton 2, New Jersey

DL 262

WHY SHELL-MOLDED BRONZE BEARINGS COST LESS AND WEAR LONGER



National Bearing's carefully controlled *shell molding* practice makes extremely close-tolerance casting possible. This eliminates the need for costly machining and metal waste. It permits retention of a greater portion of the tough outer cast shell... *a guarantee of greater service life.*

Add to this the fact that if oil grooves are required, they can be cast in; if drilling is specified, castings are drilled prior to shipment so that they are ready for installation when received by you... and you have the answer to why *shell-molded* bearings cost less and wear longer.

And remember, six modern National Bearing plants insure quality workmanship and prompt delivery. They, in turn, are backed by extensive engineering and research facilities of the entire American Brake Shoe Company.

So investigate National SM castings for use as line shaft, crane, run-out table, and other similar replacement parts.

OTHER NBD PRODUCTS FOR THE STEEL INDUSTRY

Bosh Plates	Stack Plates
Monkeys	Roll Neck Bearings
Tuyéres	Housing Nuts
Coolers	Babbitt Metals
Mantle Plates	Slippers

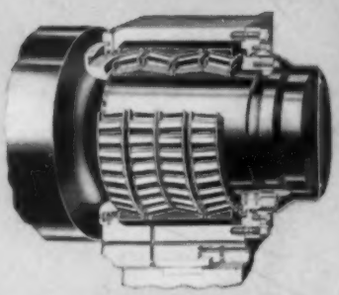
AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue, St. Louis 10, Mo.

1,824 TIMKEN® bearings in two United mills!

Result: *constant pass alignment, simplified lubrication*



UNITED ENGINEERING & FOUNDRY CO. installed a total of 1,824 Timken bearings in these two continuous bar and billet mills in service at a large midwestern plant to insure long life, minimum maintenance. Performance has been excellent.

SEVERAL years ago, United Engineering built these two modern high-speed 20″ x 36″ and 30″ x 48″ continuous bar and billet mills with alternate vertical and horizontal stands for a big midwestern steel producer. All told, they used *1,824 Timken® tapered roller bearings* in the two mills—on the roll necks, in the drives, on the run-out tables and in other vital applications.

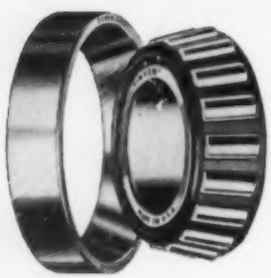
Timken roll neck bearings permit maximum roll neck size and provide greater mill rigidity. Higher rolling speeds are possible. Mills can be started or stopped without loss of steel. Pass alignment is accurately maintained by Timken roll neck bearings *without* the use of auxiliary thrust bearings. Due to their tapered construction, Timken bearings take radial and thrust loads in any combination.

With Timken bearings there are no complex lubrication systems for roll neck bearings. They use simple economical grease lubrication. This eliminates a possible source of trouble, speeds up roll changes, reduces maintenance.

Here are more significant bearing facts to consider: Timken bearings have extremely low frictional resistance due to their true rolling motion and *incredibly* smooth finish. They have extra load carrying capacity due to full line contact between rollers and races. They hold shafts and housings concentric, making closures more effective; dirt stays out, lubricant stays in.

When you buy equipment, look for Timken bearings. When you build equipment, look into Timken bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian Plant: St. Thomas, Ont. Cable address: "TIMROSCO".

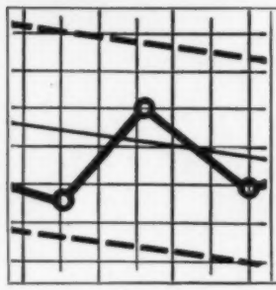
This symbol on a product means its bearings are the best.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



STATISTICAL QUALITY CONTROL

To insure uniform high quality and closer tolerances, the Timken Company uses statistical quality control. With it, tolerance deviations are plotted graphically. It's one of industry's newest, most scientific methods of improving product uniformity.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↓ AND THRUST → ← LOADS OR ANY COMBINATION ↔

Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington, D. C., at 25 cents each . . . . patents reviewed cover period April 6, 1954, through May 4, 1954 . . . .

BLAST FURNACE CHARGING DEVICE

▲ U. S. 2,674,382, issued April 6, 1954 to Erik T. A. Tesch and Isak E. Johansson, relates to an improvement in blast furnace charging devices. The method of only allowing the material to pass through a cone when falling into the shaft furnace, which is now usually practiced, does not result in the desired distribution, owing to the tendency of the material to separate according to size and specific gravity. The rising gases follow the law of least resistance, and thus they flow more amply where coarser material is concentrated and the charge is looser than where there is finer material and the charge is correspondingly tighter. This will cause uneven reduction of the ore in the material and the useful volume of the furnace will be less effectively utilized. Disturbances in operation may also result on account of the gas forming irregular passages in the material.

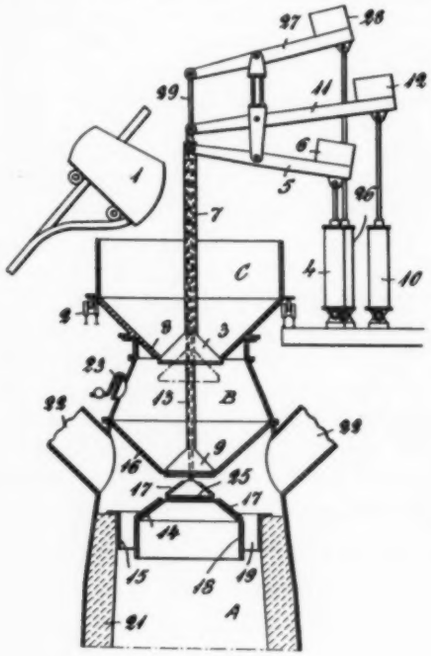


Figure 1

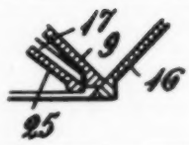


Figure 2

In order to obtain a better distribution of the material it has been suggested to close the opening of the cone-shaped bottom of the charging top by means of a conical valve which, in order to empty the charging top, may either be raised above its closing position, when the material is to fall into the center of the furnace, or be lowered below said position, when the material is to fall outward towards the furnace wall.

This device, however, has disadvantages inasmuch as the height of fall of the material is changed when the conical valve is moved from a position above the opening in the bottom of the charging top to a position below.

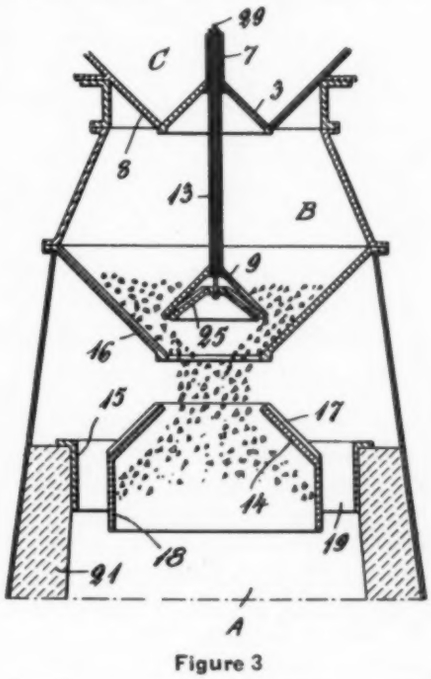


Figure 3

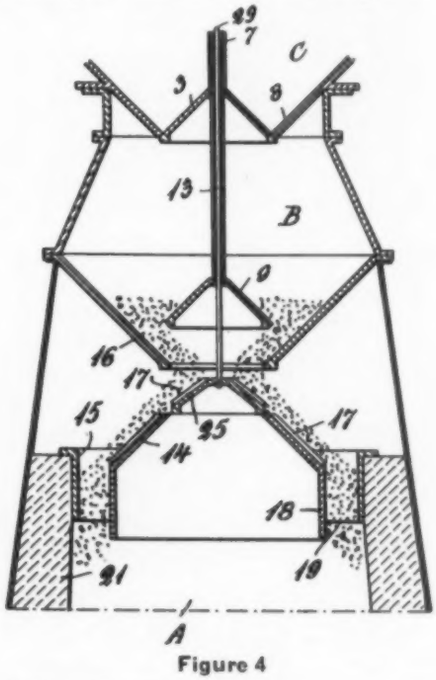


Figure 4

The present invention overcomes this change in the height of fall of the material. The device is shown in Figures 1-4.

The shaft furnace is designated A, the lower container of the double

charging top is designated B, and its upper container C. The latter is preferably rotatably mounted on rollers 2. The material is supplied to the furnace by the self-tilting wagon 1. After a sufficient quantity of material is supplied to the container C, the conical valve 3 is lowered by means of the compressed air cylinder 4, the lever 5 with its counter-weight 6 and the hollow supporting rod 7. The charge material will thus slide down from the container C to the container B, whereupon the container C is closed by the valve 3, again being raised against the conically shaped bottom 8 of the container.

After this the material is dropped from the container B into the shaft furnace A either by raising both conical valves 9 and 25 as shown in Figure 3, thus allowing the material to fall down into the centre of the furnace, or by lowering the valve 25 and raising the valve 9 as shown in Figure 4, causing the material to slide down around the wall 21 of the furnace A. In order to protect the wall against wear there is a lining 15. The valve member 25 and distributor 14 carry radial ribs 17 on their upward surfaces, for guiding the stock flow.

Figure 2 shows in detail how the valve 9 tightly engages the bottom 16 of the container B, and how the valve 25 fits into the valve 9.

LOW-TEMPERATURE IRON PRODUCTION

In U. S. 2,674,531, issued April 6, 1954 to Marvin J. Udy, reduction is carried out below the melting point of iron, just below the fusing temperature of the slag, so that sintering of the charge occurs. The first step in the process is the low-temperature reduction, and this is followed by a melting step.

Solid carbonaceous material and a flux such as lime and silica are added to the charge, which is intimately mixed and finely ground. A slag is produced having a molal ratio of lime to silica of between 0.7 and 3.0. The sintering may be performed in a rotary kiln, a tunnel kiln, or a Dwight-Lloyd machine. The hot sintered product is delivered to the melting furnace. In some cases, only partial reduction may be carried out in the sintering step, the remainder being accomplished during the melting step.

The process may be operated advantageously to utilize high-phosphorus ores by using two electric melting furnaces. The process is capable of high-tonnage production when a rotary kiln is used for the sintering step. In this case, fine scrap may be added to the charge.

It is claimed that the process makes economical electric furnace smelting of pig iron, because the amount of power required is reduced substantially to that required for refining. Larger electrical furnaces may be used, at high power factors. There is maintained a sufficiently heavy slag layer to provide for efficient melting and for carrying the power into the furnace at high efficiency.

The process also makes it possible to use lower grade ores, without the use of coke.

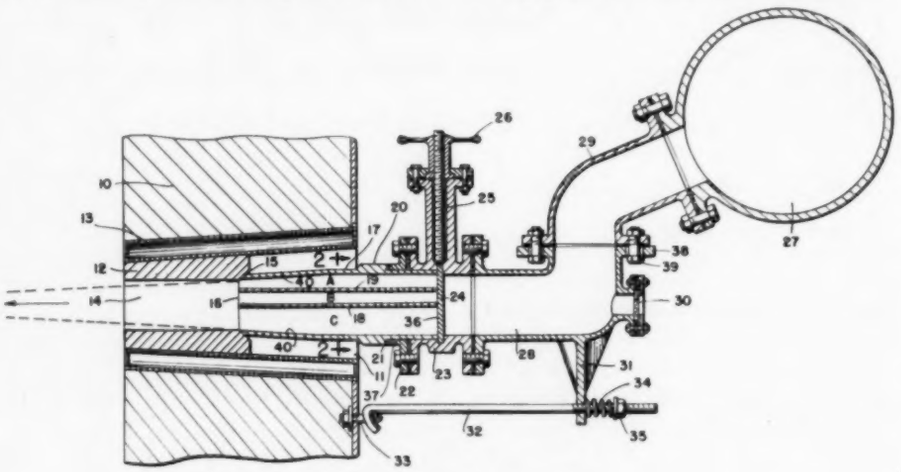


Figure 5

BLAST-FURNACE HOT-BLAST VELOCITY CONTROL

Better combustion and heat concentration within the hearth of a blast furnace are obtainable by a method of control of the velocity of the hot blast, according to Frank L. Luckey. The patent, U. S. 2,676,012, was issued April 20, 1954.

The apparatus used is shown in Figure 5. The tuyere 12 fits the inner wall of the notch 11. The notch 11 is water-cooled by jacket 13. The blow pipe 17 is beveled to fit the conical seat 15 of the tuyere. The interior of the blowpipe is subdivided by parallel horizontal baffles 18 and 19. A gate valve 23 is connected to the blow pipe, as shown. The valve has a gate 24 with a threaded stem 25 and hand wheel 26. The ends of the partitions 18 and 19 fit against the face of the gate 24. The valve is connected to the bustle pipe 27 as shown. A window 30 is provided through which the operator may observe the condition of the contents of the hearth in any of the open positions of the gate, (i.e. when passage C is open, or C & B, or C, B & A).

The partitions 18 and 19 are so located in the blowpipe as to divide the effective passage in definite ratios. For example, the area of passage C might be equivalent to that of a 5-in. pipe, that of passage C plus B to a 6-in. pipe, and C plus B plus A to a 7-in. pipe. The shifting of the gate 24 changes the volume of air delivered to the tuyere while the velocity remains substantially constant.

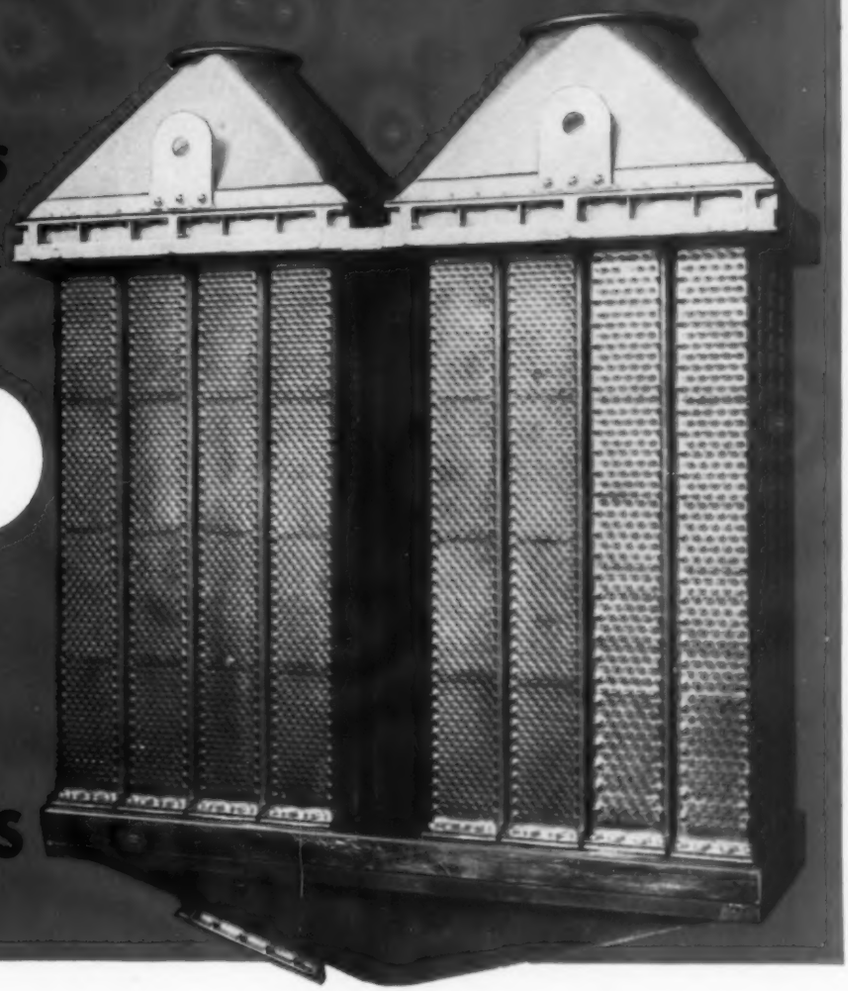
An operator familiar with blast furnace practice can determine by looking into the window 30 whether the furnace is functioning properly in the vicinity of the tuyere, and whether or not the efficiency can be improved by increasing or reducing the volume of air blast to combat an irregularity in the temperature of the hearth.

APPARATUS FOR CONTINUOUS CASTING OF STEEL

An apparatus for continuous casting steel is described by Irving Rossi, Rufus Easton, and T. Yates Wilson in U. S. 2,674,019. The patent, issued April 6, 1954, is assigned to Continuous Metalcast Co.

The apparatus is shown in Figure 6. The floor 1 of the reservoir in which the molten metal is maintained is provided with an aperture 2 through which the molten metal flows through a conduit 3 which conducts the molten metal to the casting mold 4. The flow of molten metal through the

Cut Your Heating Costs With TTC



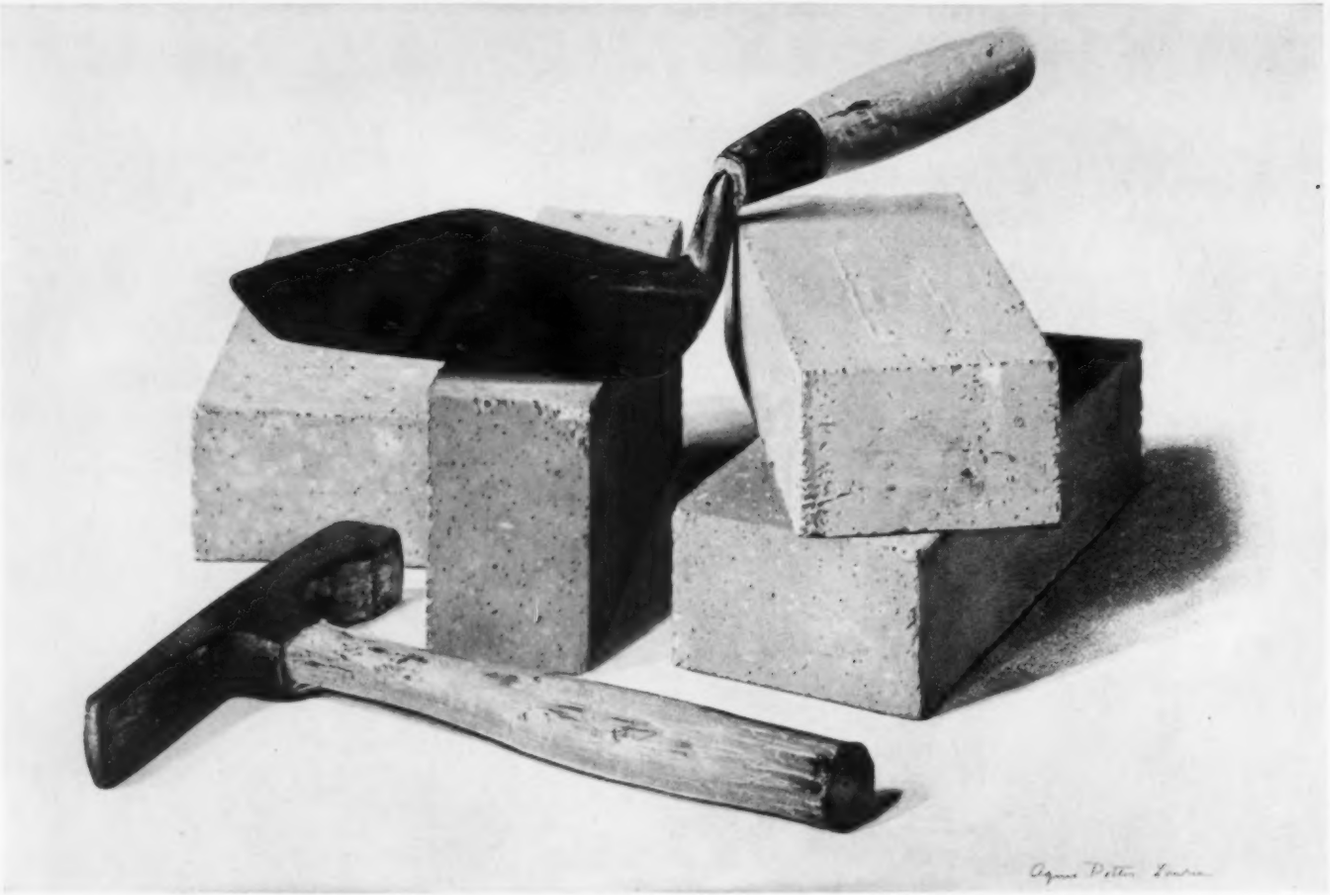
Needle-type Metallic Recuperators

TTC Needle-type Metallic Recuperators guarantee substantial fuel economies. Years of experience in the plants of the nation's leading steel producers and fabricators offer time-proven performance. Flexibility of application and long, trouble-free service-life assure TTC recuperator efficiency. The design eliminates leakage and minimizes pressure and draft loss.

Write or phone for a TTC recommendation to help reduce your heating costs.

Thermal Transfer Corporation

601 Columbia Building • Pittsburgh 22, Pa. • ATlantic 1-0437



"Lining for the Furnaces" by Agnes Potter Lowrie, famed artist daughter of a noted steelmaker. In this second of a specially commissioned series, Mrs. Lowrie captures the deceptively soft, seldom seen texture of refractory brick so rugged it can withstand months of searing 3000° temperatures . . . Limited edition of 15 x 18 color prints available. Complimentary copy sent upon request.

The Fine Art of Steel Making #II

Whether it's building bridges or bombers, skyscrapers or pipelines . . . when America grows, it calls on steel. Year after year the industry has met the demand for more steel, better steel, faster and more efficient production. Today's speedy, almost automatic four-high mill, for instance, rolls in a single 8-hour shift more steel than the old-time hand mill produced in a week.

As the mechanics of steel making improved, so have the materials which smooth the process — Ironsides roll neck and roller bearing lubricants.

Roll neck shield, once applied by hand, is now supplied in liquid and semi-liquid form for continuous application by automatic pressure systems. Roll necks may be kept at constant temperature; the roller need not adjust his mill to maintain proper gauge.

More important, roll neck shield is formulated to the special needs of the individual user. For example, to compensate for local water and temperature conditions or to meet personal preferences of mill superintendents.

Roller bearing shield, an extreme pressure lubricant, has load-carrying capacity in excess of bearing manufacturers' standards, assuring a safety factor for peak loads. It carries the approval of all top bearing makers.

Today almost every major steel producer is a user of Ironsides lubricants. Our unique position in the industry is due to our ability to formulate for individual applications and supply those special formulas in any quantity.

We like tough problems; we've solved a lot of them. For example, Palmoshield, replacement for palm oil and most significant advance in lubrication since World War II. If you have a problem, we'd like to help lick it. A letter will summon one of our engineers. Address The Ironsides Co., Columbus 16, Ohio.

SHIELD PRODUCTS

Ironsides

By the makers of Palmoshield • "the palm tree that grows in Ohio"

aperture 2 is controlled by a valve 5.

The invention has to do with the construction of the conduit 3 and valve 5 in order to enable these to withstand the temperatures of molten steel for considerable periods of time.

The valve 5 consists of a tubular metal shell 6 with walls heavy enough to provide the required mechanical strength. The lower end of the shell carries a plug 7 of refractory material which seats against the aperture 2.

The shell 6 supports and is surrounded by a refractory tubular sleeve 8, concentric with it and seated on the plug. The upper end of the

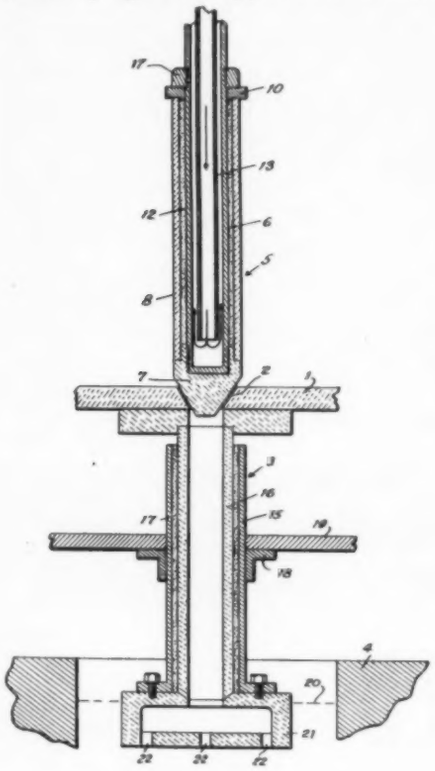


Figure 6

sleeve 8 is held in place by the washer 10. The space between the shell 6 and sleeve 8 is filled with powdered or granular refractory material 12.

The interior of the shell 6 is cooled by a cooling fluid such as water or air. The cooling fluid is introduced through a tube 13, circulating in the direction shown by the arrows.

With this construction, the metal shell 6 is constantly cooled by the cooling fluid and retains its strength as a supporting member for the refractory tube 8. Furthermore, the cooling effect on the plug 7 reduces the effect of the molten steel on it, without however, causing molten metal to freeze on the plug.

The combination of the refractory tube 8 and the layer of powdered or granular refractory material 12 serves to prevent the freezing of molten metal on the outer surfaces, and has been found exceptionally satisfactory for this purpose, not only because of the good insulating value of the finely divided refractory, but also because

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,674,250-1 and 2,674,550-1	4/ 6/54	Metal strip cleaning apparatus	Kolene Corp.
2,674,446	4/ 6/54	Stack closure assembly for melting furnaces	Reda Pump Co.
2,674,455	4/ 6/54	Apparatus for automatically positioning metal strip on rolls	United States Steel Corp.
2,674,760	4/13/54	Tube cleaning apparatus	Jones & Laughlin Steel Corp.
2,674,926	4/13/54	Apparatus for circumferentially milling steel ingots	August Saxer
2,674,941	4/13/54	Device for marking sheet or strip	Bethlehem Steel Co.
2,675,125	4/13/54	Direct and indirect extrusion of metals	Reginald Genders
2,675,215	4/13/54	Benzol spray scrubber	Carl Otto
2,675,223	4/13/54	Draft sintering apparatus	Ole Rolfsen
2,675,296	4/13/54	Treating gas containing ammonia and acidic gases for recovery thereof	Koppers Co., Inc.
2,675,308	4/13/54	Using magnesium-containing addition agents to produce spheroidal graphite cast iron	The International Nickel Co., Inc.
2,675,461	4/13/54	Heating metallic wire, bars, and strips	Samuel E. Leonard
2,675,720	4/20/54	Coiler and feeder assembly for reversing rolling mills	Crucible Steel Co. of America
2,675,864	4/20/54	Burner for open-hearth furnaces	Jay J. Seaver
2,675,918	4/20/54	Magnetic separator	The Jeffrey Manufacturing Co.
2,675,969	4/20/54	Impact apparatus for disintegrating solids	Lukens Steel Co.
2,676,007	4/20/54	Heat-treating apparatus	Alvin W. Davis
2,676,008	4/20/54	Heat treatment and drying only on the surface of substances in continuous furnaces	Theo Munker
2,676,011	4/20/54	Construction for the tap holes of open-hearth furnaces	Loftus Engineering Corp.
2,676,097	4/20/54	Composition for addition to cast iron or steel	Vanadium Corp. of America
2,676,098	4/20/54	Drill rod steel	Crucible Steel Co. of America
2,676,146	4/20/54	Apparatus for determining the proportion of tin deposited electrolytically on each side of a steel strip	United States Steel Corp.
2,676,232	4/20/54	Method of thoroughly heating electrolytically to forging temperature large billets	Allmana Svenska Elektriska A.G.
2,676,368	4/27/54	Permanent mold casting machine	General Motors Corp.
2,676,369	4/27/54	Apparatus for casting and rolling steel into continuous strips	Edward J. Stark
2,676,502	4/27/54	Universal rolling mill	Sven E. M. Norlindh
2,676,599	4/27/54	System for pickling	Allegheny Ludlum Steel Corp.
2,676,793	4/27/54	Open hearth furnace	Herbert Jones
2,676,834	4/27/54	Equalizer link for multiple-branch slings	United States Steel Corp.
2,676,900	4/27/54	Removal of oxides from the surface of metals	Hooker Electrochemical Co.
2,676,915	4/27/54	Device to pack coal in coke ovens	Leon M. L. Dupre
2,677,174	5/ 4/54	Device for pulling blast furnace bosh plates	United States Steel Corp.
2,677,277	5/ 4/54	Apparatus for measuring the temperature of a heated body in an enclosure	Leeds and Northrup Co.
2,677,538	5/ 4/54	Apparatus for preventing piled sheet iron from sintering together during annealing	Allmanna Svenska Elektriska A.G.
2,677,541	5/ 4/54	Roll for automatically centering moving objects	United States Steel Corp.
2,677,570	5/ 4/54	Lifting device for wire rope reels	Jones & Laughlin Steel Corp.
2,677,593-7 and 2,677,606-7	5/ 4/54	Preparation of ferrous chloride from mixed chlorides	Republic Steel Corp.
2,677,610	5/ 4/54	High-temperature alloy steel	Universal-Cyclops Steel Corp.
2,677,628	5/ 4/54	Cleaning refractory checkerwork in blast furnace stoves	Lawrence R. Robinson
2,677,652	5/ 4/54	Electrotinning continuous steel strip	United States Steel Corp.
2,677,710	5/ 4/54	Furnace structure for use in melting a consumable electrode in a crucible	Allegheny Ludlum Steel Corp.

the combination provides a structure which can continue to operate satisfactorily even though the sleeve 8 may crack due to thermal shock. In the event of cracking, the influx of molten metal will be stopped by the powdered or granular refractory acting as a seal.

A similar principle of construction is employed in the conduit 3 in which a tubular supporting member 15 of metal, preferably steel, is spaced from the refractory conducting tube 16 by a layer of powdered or granular refractory material 17. The conduit is supported by the flanged collar 18 secured to a support 19. Ordinarily the metal tube 15 is cooled sufficiently by radiation and convection, although it may be additionally cooled by air blast or water jacket, if desired.

Again, as in the case of the valve 5, even in the event of cracking of the refractory tube 16, the escape of molten metal will be prevented by the powdered or granular refractory material acting as a seal.

The powdered or granular refractory material should be of a type having a fusing temperature higher than the melting point of steel. Powdered or granular magnesia, zirconia, silica or alumina are examples of satisfactory materials. This powdered or granular material should be placed in the spaces provided in loose form, without the use of binder of any kind.

In some cases, the molten metal may be discharged directly from the bottom of the tube 16, but it is usually advisable to use a distributor at the bottom of the tube to break or direct the flow of molten metal. Such a distributor is shown, consisting of an enlarged head 21 of refractory material secured to the flanged end of the tube 15. The molten metal flows into the mold 4 through apertures 22. The usual level of molten metal in the mold is indicated by the numeral 20.

MANUFACTURE OF LOW-CARBON STAINLESS STEEL

U. S. 2,674,529, by Walter Crafts, and U. S. 2,674,530, by Herman P. Rassbach, relate to processes for finishing low-carbon (less than 0.03 per cent) stainless steels in a basic lined furnace. The patents, issued April 6, 1954, are assigned to Union Carbide and Carbon Corp.

An electric arc furnace having carbon electrodes is charged with carbon steel scrap and stainless-steel scrap. The scrap is melted and decarburized with oxygen until the carbon content is about 0.015 per cent. Then for the finishing operation, the furnace is provided with a slag having a base-acid ratio of 0.7 to 1.6, by adding silica under each of the electrodes (as compared to 2.0 for conventional basic slags). The resulting carbon pickup is shown graphically in Figure 7.

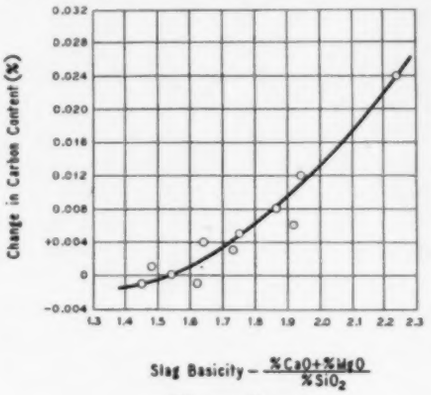
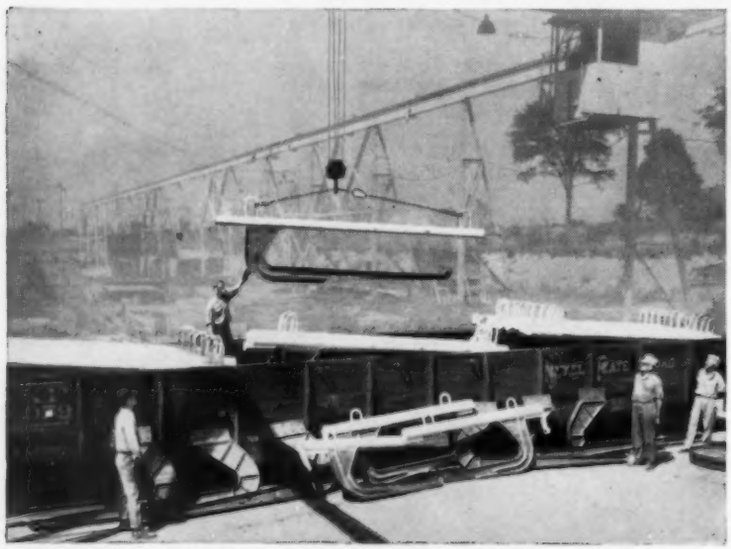


Figure 7



LIGHTWEIGHT HOOKS *for* HEAVY-DUTY SERVICE

WELDCO HAIRPIN HOOKS SPEED UP YOUR PICKLING AND MATERIAL HANDLING OPERATIONS

● Here's another carload of Weldco hairpin hooks, ready for shipment to one of the country's largest steel plants. These pickling hooks are lightweight but **tough** . . . designed to handle loads as heavy as 3,000 to 5,000 pounds, easily and safely. Weldco hairpin hooks withstand hot pickling acids, too; in fact, they're more corrosion-resistant—more durable—than many heavier hooks.

Weldco pickling hooks are made of Monel, and can be furnished in various other alloys. Put these sturdy, lightweight hooks to work in your plant—then watch your pickling and material handling costs go down.

OTHER WELDCO PICKLING PRODUCTS
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3700 OAKWOOD AVENUE . . . . YOUNGSTOWN 9, OHIO

RECORD HORSEPOWER. G-E main drive system for world's fastest cold mill at Fairless has record total horsepower of 21,650. This triple-armature twin drive packs 6000 horsepower into No. 5 stand.

Drive-engineered by General Electric . . .

World's fastest cold mill rolls at 7000 fpm

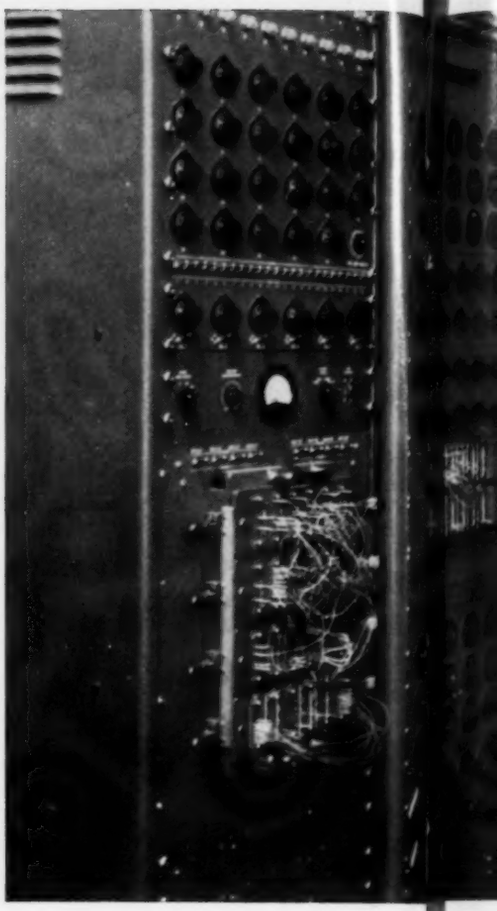
Showcase of the steel industry, the new Fairless Works of United States Steel at Fairless Hills, Pa., reflects the latest in drive engineering and equipment —much of it General Electric. Typical is this 5-stand tandem cold reduction mill, powered by a General Electric drive system.

Fastest in the world, this cold mill speeds at 7000 feet per minute—almost 80 miles per hour—delivering two tons of .009-inch-thick strip per minute. Acceleration from standstill to top speed takes only ten seconds. And the combined 21,650 horsepower of its main drives is also a record for this type of mill.

G-E designed individual-generator control gives the mill greater flexibility and simplicity of operation, plus a higher percentage of "on-gage" strip. G-E drive motors, specially designed to reduce stored energy to a minimum, permit acceleration and deceleration at the high rates required. And responsive auxiliary drive system helps assure accurate control of gage and shape of strip even at these high speeds.

See next page for design story ▶

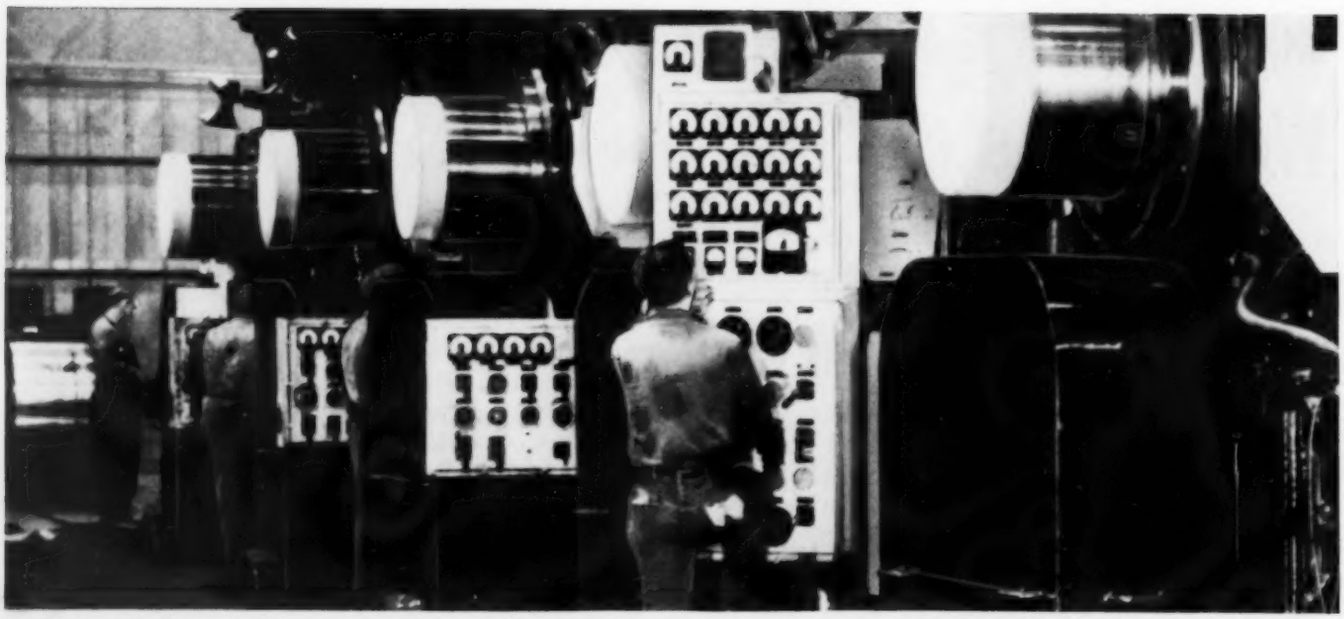
GENERAL ELECTRIC



APPLICATION ENGINEERING—On the job from early planning stages through start-up, G-E Application Engineers like W. E. Miller (left) helped design and install drive system. Here, he discusses 5-stand mill control with U.S. Steel engineers.

At record-breaking Fairless Cold Mill . . .

General Electric engineering services



PRODUCT ENGINEERING—One man has control of 5-stand mill from main control board at No. 2 stand. G-E Product Engineers designed special control equipment which continuously monitors performance, and perceives and corrects variations.

ANALYTICAL ENGINEERING—New circuitry for the 7000-fpm mill was developed using computers such as this electronic differential analyzer being operated by G-E Analytical Engineer F. S. Rothe. Application Engineers C. C. Thomas and R. G. Beadle check results of a "run" of the mill just completed on the analyzer to eliminate problems before installation.

save planning time, speed start-up

FIELD ENGINEERING—Helping with mill's installation and start-up operations, G-E Field Engineers H. L. Peacock (left) and C. E. Batchelder test differential relays with a U.S. Steel engineer.

Key factor in the success of Fairless' cold reduction mill drive was the over-all system approach which co-ordinated the electric and process equipment. U.S. Steel and Mesta engineers, working with G-E engineers as a team, designed the 21,650-hp main drive system.

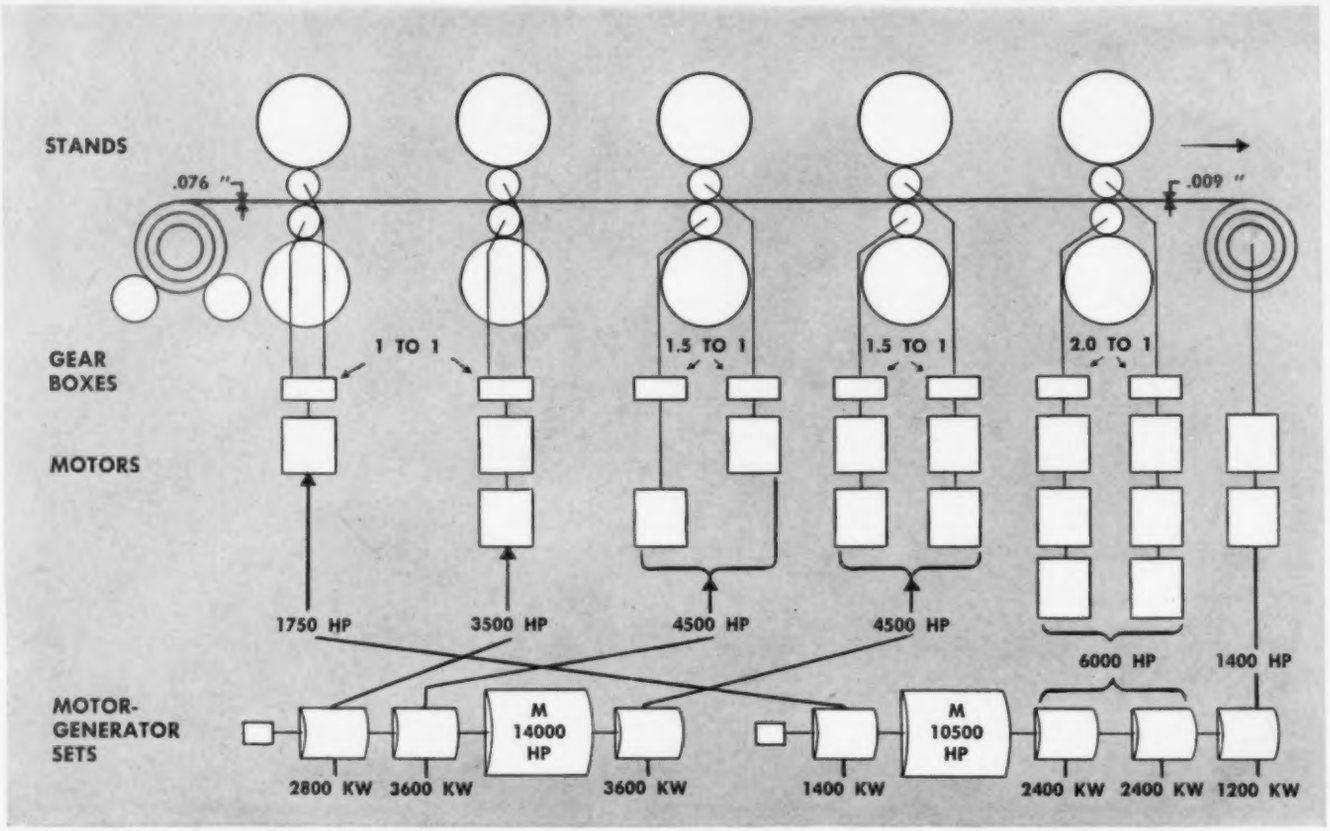
Backing them up were G-E engineers who "ran" the mill on electronic computers to eliminate problems before installation, designed new control and drive circuits, assured the right equipment arrived at the right time, and helped start up the mill.

Whatever *your* steel-mill electrical requirements, these and other G-E engineering services are available to help you achieve higher speeds for greater output, more accurate control of product quality, and lower unit costs to meet today's demands. Your local G-E Apparatus Sales representative will put them at your service. Contact him early in the planning stage. General Electric Company, Schenectady 5, N. Y.

See next page for engineering details ▶

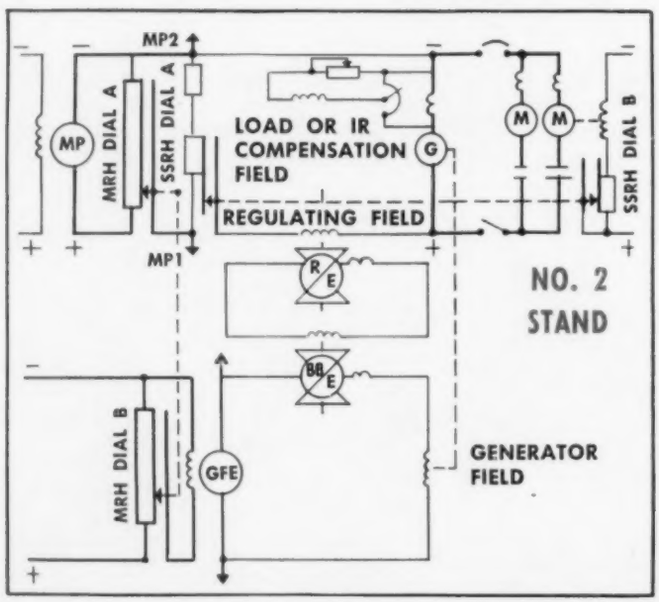
GENERAL ELECTRIC

Another example of G-E drive engineering at work!



17 MAIN DRIVE G-E MOTORS, RANGING FROM 700 TO 2250-HP, DRIVE 5-STAND TANDEM COLD REDUCTION MILL

G-E individual-generator control helps keep strip "on-gage" at Fairless Mill



How G-E individual-generator control works

In control circuit of No. 2 stand (left), mill master rheostat MRH determines voltage on master voltage control bus MP1 and MP2, which is the standard by which each generator's voltage is controlled. By raising or lowering voltage on this bus, voltage of all generators may be raised or lowered in proportion. Mill master rheostat also controls excitation on generator-field exciter GFE, which supplies all stand generators. In this way, regulating amplidynes RE and BBE on each stand can operate at low voltage levels ideal for fast regulator action.

Individual voltage adjustment on each generator is determined by stand master rheostat SSRH. Each stand-motor's speed is also controlled by adjustment of its shunt-field current by this same rheostat.

Load, or ohmic-drop compensation, is provided in the regulating system to insure the maximum amount of "on-gage" strip during acceleration, running, and deceleration of the mill.

To accelerate the mill to threading speed, then to running speed, and then back to threading speed, operator need only press respective buttons on conveniently located control cabinet. A full complement of indicating instruments is provided for operator to check speed, load, tension between stands, winding-reel tension, and gage during rolling operation.

659-102

GENERAL ELECTRIC

trantinyl

guides the steel industry

ROLLING MILLS:
bar, hoop, strip, shape
mill guides; and rollers

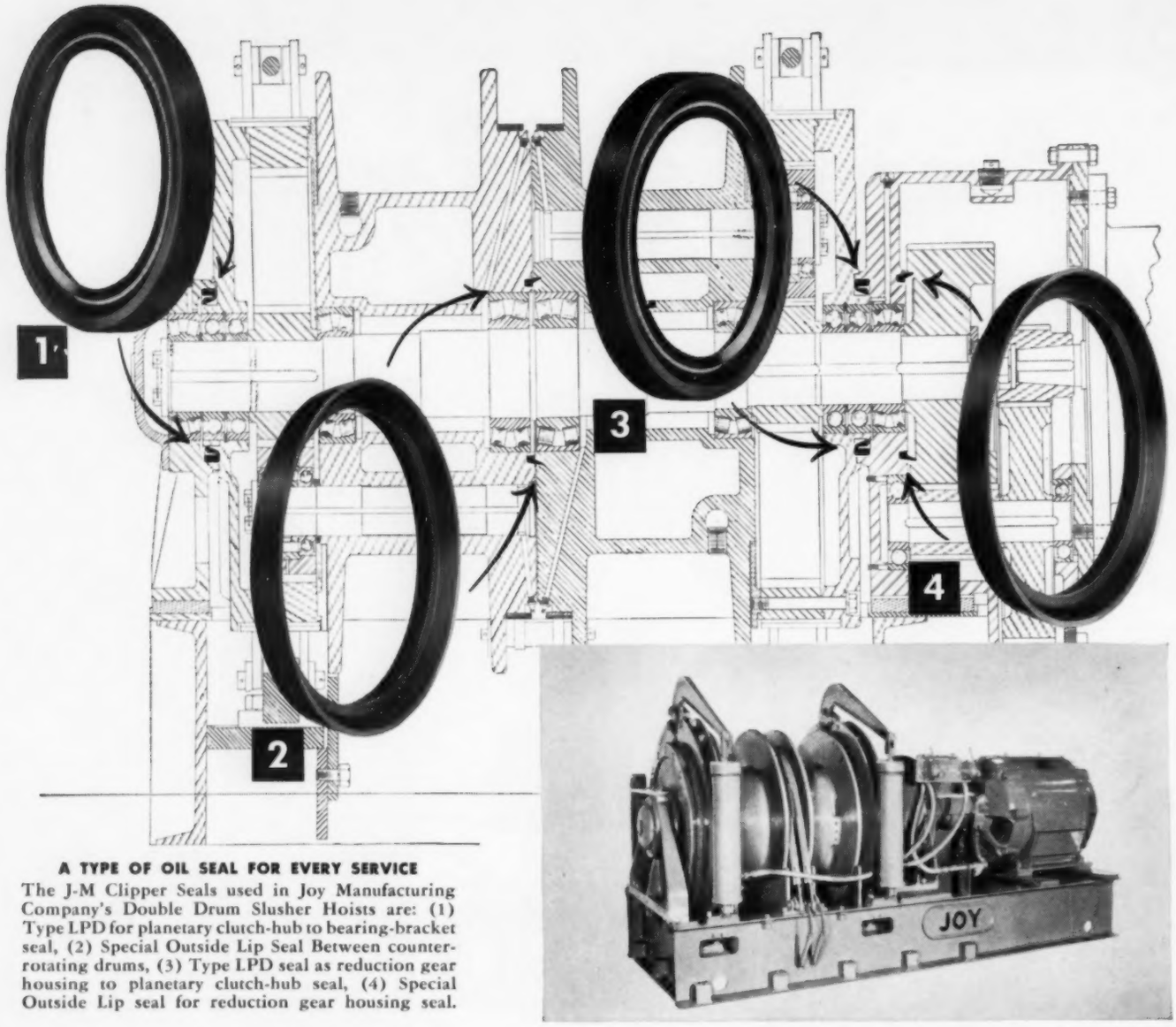
SEAMLESS TUBE MILLS:
guide shoes, rolling
mill plugs and rolls,
piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing
rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

YOUNGSTOWN ALLOY CASTING CORP. • YOUNGSTOWN, OHIO



A TYPE OF OIL SEAL FOR EVERY SERVICE

The J-M Clipper Seals used in Joy Manufacturing Company's Double Drum Slusher Hoists are: (1) Type LPD for planetary clutch-hub to bearing-bracket seal, (2) Special Outside Lip Seal Between counter-rotating drums, (3) Type LPD seal as reduction gear housing to planetary clutch-hub seal, (4) Special Outside Lip seal for reduction gear housing seal.

Need an oil seal to withstand muck and acid mine water?

Clipper Oil Seals help Joy Mine Slushers stay underground longer

THIS 125 H.P. Double Drum Slusher Hoist made by Joy Manufacturing Company is one of the most rugged machines in underground mining service. Designed to haul rock and ore in metal mining operations, it is constantly covered with muck and mud. In addition it is subjected to acid mine waters. To work dependably, shift after shift, day after day, it must stay clean and well lubricated on the inside.

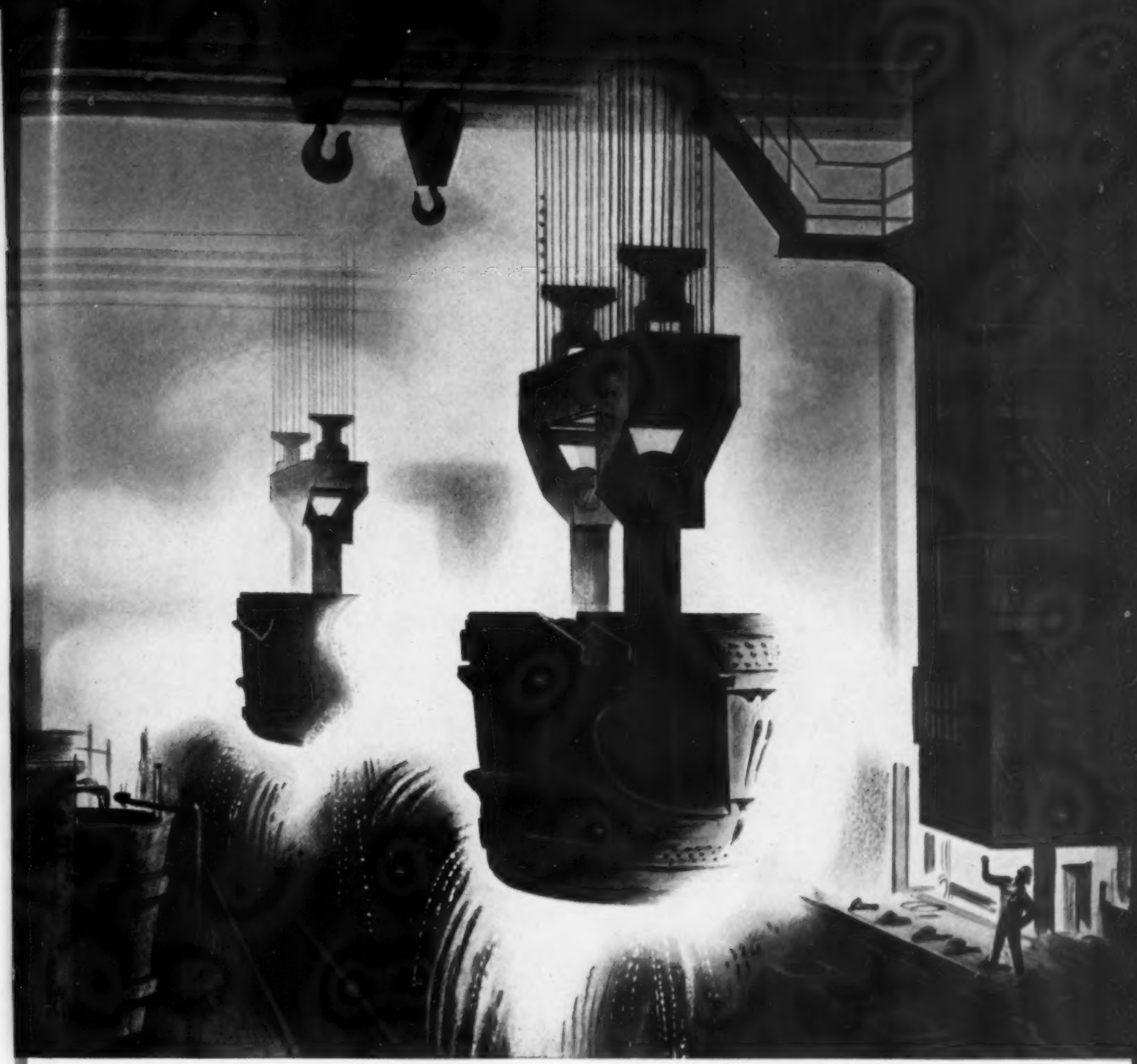
To protect its bearings from dirt and corrosion and to retain the lubricant, two types of Clipper Seals are used. Type LPD Clipper Seals with corrosion-resistant alloy garter springs are installed on the reduction gear housing to planetary clutch and on the planetary clutch hub to bearing housing. Special outside lip springless Clipper Seals are installed between the counter rotating drums and on the reduction gear housing. This combination was effected by Johns-Manville Packing Engineers working in conjunction with the Joy Manufacturing Company engineering staff.

Clipper Seals offer many advantages, wherever accurate fit, longer life and greater sealing effectiveness are required. These precision-moulded oil seals provide easy installation, because the tough, dense heel affords just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

Clipper Seals come in a wide variety of designs, to meet practically any sealing requirement. For details write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER OIL SEALS



MORGANIZATION...way to cut costs

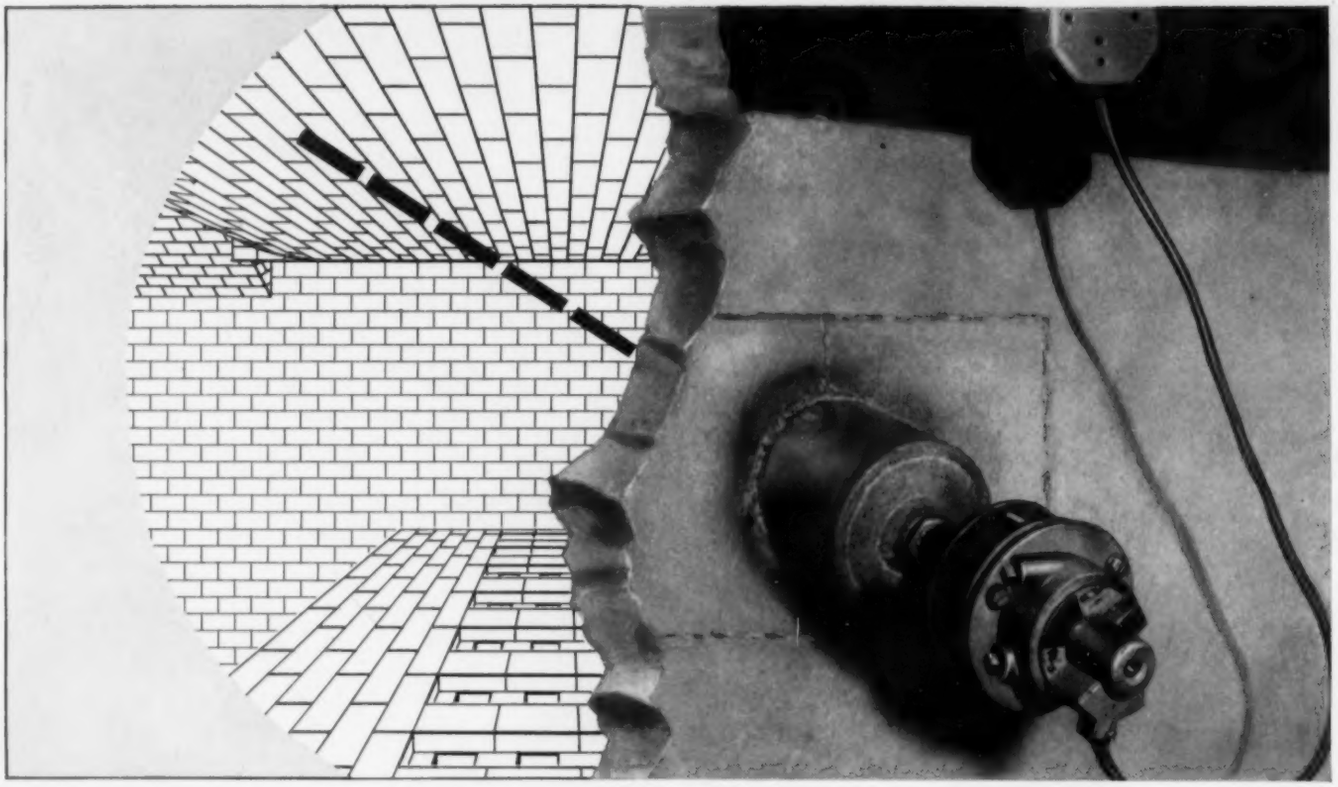
They expected a minimum of 20 years of service from the special-purpose Morgan crane we built for their steel mill. Already this steel company has received 39 years of service, almost double the expected life... and the end is still nowhere in sight. And, of course, the yearly expected cost of operating the crane has been reduced.

This is a typical result of "Morganization"... surveying, designing, building, and installing with the experience and *extra care* that make Morgan cranes and rolling mills and special equipment *last a lot longer*... and that make Morgan equipment cost less over those added years.

Write for booklet E-8, which describes "Morganization" and Morgan equipment for heavy service.

MORGAN ENGINEERING

THE MORGAN ENGINEERING COMPANY, ALLIANCE, OHIO



Guard the

critical temperature zone

of your checkers with RAYOTUBE® DETECTORS

Proper protection of checker chambers from overheat damage requires a temperature measurement right at the point where the hot combustion gases enter. It's here that these gases usually do the most damage. It's here that you need a temperature record to guard against destructive over-heating . . . damage to checkers . . . and production losses through down-time. It's here that you want a sturdy, dependable, yet sensitive temperature detector.

And it's right at this point, that the L&N Rayotube detector goes to work for you—sighting directly on checker or fan tail arch, reporting temperature accurately, and staying on the job, day in and day out.

Because this detector is hermetically sealed at its viewing lens, at its quartz window, and at the leadwires, dust and dirt just don't get in . . . calibration remains dependable. Ambient heat won't damage the Rayotube or affect accuracy, even when the temperature of its housing goes to 350 F. And beyond 350 F, a forced cooling system keeps the Rayotube safe and efficient.

The mounting and installation of the checker Rayotube assembly is relatively simple. In the majority of checker applications, an air purge is not required to keep the sighting tube free from fumes and dirt. However, connecting an air line to the Rayotube makes purging available when it is needed.

These Rayotube detectors—in addition to protecting checkers—can be used, in a control system, to initiate balanced O-H reversals based on temperature-difference of the checkers themselves.

If you're interested in L&N Rayotube detectors and the Speedomax instruments used with them for checker applications, you can obtain more information from your nearest L&N representative or by writing Leeds & Northrup at 4942 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
instruments *automatic controls* • *furnaces*

Jrl Ad N-33-643(1)

Earle Browning, Manager
Steel Mill Engineering

This hot-strip mill needed smoother control and fewer cobbles

Mr. Browning shows you on the next three pages how Westinghouse apparatus and engineering assistance solved these hot-strip problems.

Westinghouse engineers had ideas for ingot buggy, runout table and coiler

When Westinghouse engineers have complete electrical responsibility, they can coordinate drives and regulating systems for the complete mill. You benefit from a boost in production, a smaller scrap pile, a mill that's easy to run.

Remote controlled ingot buggies are a step toward automation. The operator of the ingot crane, above the soaking pits, runs the show. He presses a button, and the buggy slides beneath him and stops. After loading, he presses another button, and the buggy departs to drop its ingot onto the table in front of the mill stands. Meanwhile, the crane finds a new position. The empty buggy will obediently follow it to that spot. Or the operator may ask the buggy to wait.

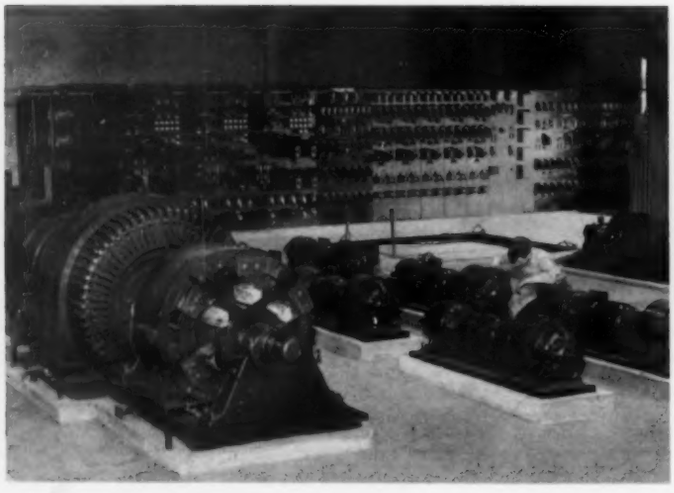
Main elements of this control are two parallel and sectionalized control rails. One is contacted by the cranes in their travel, and the other, with matching sections, provides the buggy control. These two rails form two legs of a Wheatstone's bridge. When the controlling crane and the buggy are in different locations, an unbalanced current flows. This current hurries the buggy along its track until the unbalance disappears.

To handle wide strip ranges needed on high-speed, hot-strip mills, Westinghouse has a full line of drive equipment. D-c motors driving the stands are supplied either with Ignitron rectifiers or d-c generators driven by synchronous motors. Westinghouse Rototrol® provides the precise synchronization between mill, table and coiler drives required when the strip is in both the mill and coiler and after the strip leaves the last stand of the finishing train and races into the coiler located near the mill. Westinghouse engineers carefully match all drive characteristics and coordinate the total system with Rototrol regulators.

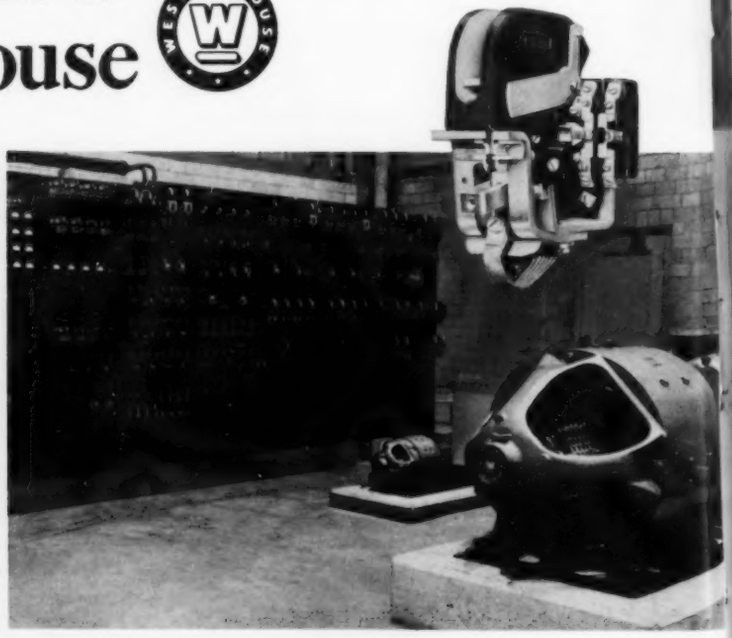
Rototrol licks a lot of mill control problems. With runout table rolls and coiler mandrels driven by individual d-c motors, each controlled by adjustable voltage, the load shifts as the strip zips from the mill along the table and to the coiler. Rototrol regulates for the speed changes and inertia effects that cause looping and cobbling. As a result, the speeds of the tables and coilers always bear a definite relationship to the speed of the mill. Simplifies your operation.

YOU CAN BE **SURE**...IF IT'S

Westinghouse

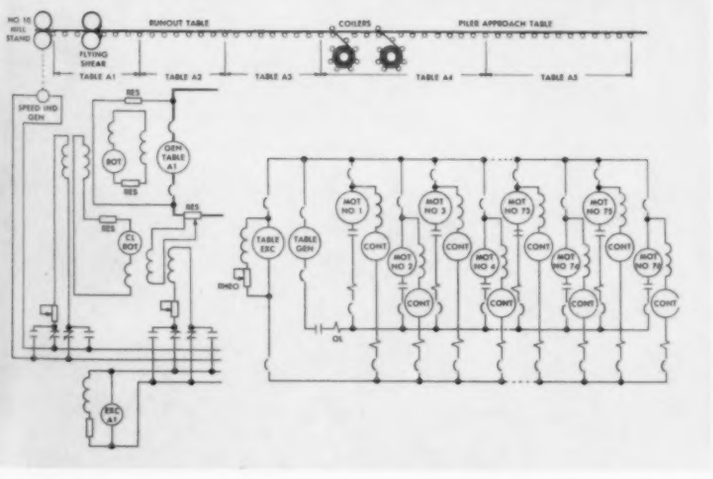


Ingot buggy control is visible at the board's left end. Rototrol regulating sets and the power supply motor generator set are in the foreground. The operator inspects one of five Rototrol m-g sets.

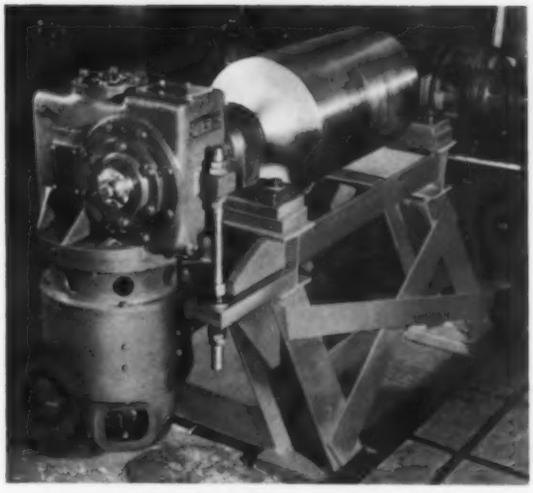


22-panel adjustable voltage control regulates runout tables and coilers. Current-limit Rototrols accelerate or retard the drive. Inset: Type M d-c contactor, a Westinghouse control line component.

700 Westinghouse d-c runout table motors each drive an individual roll on this runout table. Motors are 4-hp, adjustable voltage, totally enclosed, watertight. Each section's speed is synchronized automatically with the stand speed by this coordinated adjustable voltage system.



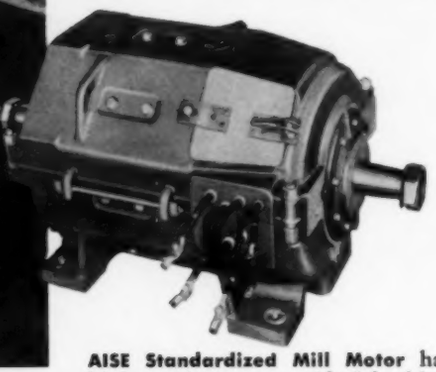
Westinghouse Rototrols match table and coiler speeds to the mill speeds. Each table section and each coiler are supplied power by an individual direct-current induction generator.



New floating-type gearmotor matched to a high-speed motor gives you an economical drive. This unit (right-angle type with worm gearing) floats with the roll. It assures alignment, saves space.

Flying shear is controlled from this desk, located in the pulpit. Both the roll diameter compensating and the cut-to-length potentiometer rheostats are in front of the operator.

New Life-Line® "A" motor has frame, feet and end brackets of heavy cast iron. Other new Westinghouse features: Bondar insulated wire; unitized stator; balanced, die-cast rotor; pre-lubricated bearings.



AISE Standardized Mill Motor has high starting torque—ideal for high inertia loads. Its simplified construction makes servicing and maintenance easy, and it performs efficiently under toughest conditions.

Flying shear and mill speeds are matched by Rototrol

On this new flying shear setup, a speed-indicating generator, mechanically connected to the last finishing mill stand, has its voltage bucked against another speed-indicating generator coupled to the shear drive. Any difference in voltage between these generators actuates the Rototrol-electronic regulator to increase or decrease the shear speed as required. A single motor forms the Westinghouse flying shear drive. It's located in the motor room—a cleaner, less cramped area. The shear is accelerated to speed in approximately three-quarters of a second. It stops just as quickly. An operation like this cuts scrap losses.

Westinghouse maintenance service will keep this rugged apparatus at peak performance. Westinghouse has 31 Renewal Parts Warehouses, 38 Repair Plants, and 56 Field Service Offices. Put our facilities to work for you. Phone your nearby Westinghouse representative. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

MP-3017

YOU CAN BE SURE...IF IT'S Westinghouse

Perry Croco, Engineering Manager in the Westinghouse Pittsburgh office, backs up the salesmen in his territory with first-class steel engineering help. Put him—or his counterpart in your area—to work for you. Ask your Westinghouse representative for these booklets: **Rototrol in the Steel Industry (B-3998-B), Westinghouse Gearmotor (B-5645), Complete Industrial Control (B-6051), New Life-Line "A" Motor (B-6154), Magamp in the Steel Industry (B-5468), Mill Motors and Controls (B-4730)** or write to: Industrial Products Advertising, Westinghouse Electric Corp., Box 868, 3 Gateway Center, Pittsburgh 30, Pa.

MP-3017

Here's important news for strip producers, processors and welded pipe producers—

BLISS ACQUIRES ALL RIGHTS TO WELD-A-MATIC SPLICERS

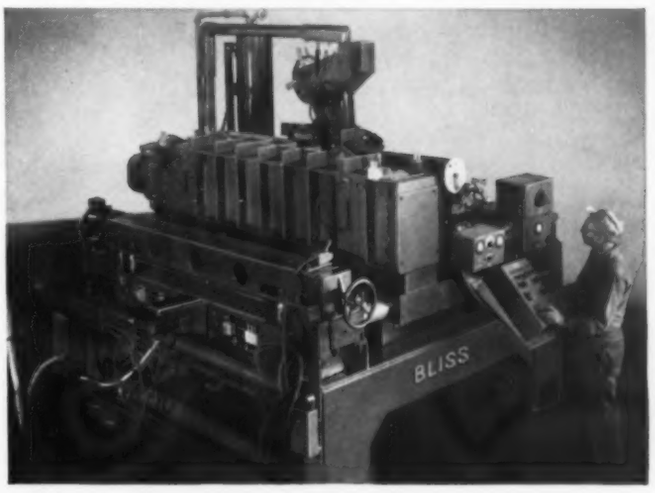
All rights to the Weld-A-Matic Splicer line used for ferrous and non-ferrous splicing have been acquired by E. W. Bliss Company from the dissolved Arms-Franklin Corporation. The agreement transfers to Bliss all patent rights, engineering drawings, service, operating and empirical data.

Weld-A-Matic Splicers are widely used for the splicing of strip for coil build-up, continuous feeding of skelp in light wall-pipe making, reuniting silicon sheets into continuous coils and many other uses.

Gages spliced range from 0.014 in. to 0.3125 in.; speeds up to 120 in. per minute depending upon gage. Weld-A-Matic Splicers are completely equipped and easy to operate, under the shielded-arc principle: no special welding skills required by operators.

E. W. Bliss is continuing research and development of the line. Though some grades of aluminum can now be welded, Bliss is seeking to widen the application. In addition, Bliss plans to manufacture two of the more popular models as standard—others will be designed to suit special requirements.

For more information, write or call for a Bliss engineer.



Remember: BLISS SINCE 1857 **for Presses, ROLLING MILLS, Special Machinery**

E. W. Bliss Company • General Office: Canton, Ohio

ROLLING MILL DIVISION: SALEM, OHIO

Subsidiary: The Die Supply Company, Cleveland, O. • E. W. Bliss (England) Ltd. • E. W. Bliss Company (Paris) France

U. S. Plants in Canton, Salem and Toledo, Ohio; Hastings, Michigan; and San Jose, Calif. Branch Offices in Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Philadelphia, Rochester, Toledo and Toronto, Canada. West Coast Representatives: Moore Machinery Co.

Galvanizing

Aluminizing

Bright Annealing and

Normalizing Strip ------ Continuously

Strip in single or multiple strands up to a total width of 54" may be bright annealed or normalized, continuously, in this EF gas fired radiant tube installation. Capacity 7200 lbs per hour.

A large capacity continuous strip normalizing, annealing and galvanizing unit. This is a combination EF gas fired radiant tube and electrically heated installation and is over 400 feet long.

We are in position to design, build and put in operation; continuous strip lines for hot or cold rolled, high or low carbon, stainless, silicon, tinplate, aluminum, brass, bronze or any other ferrous or non-ferrous strip — for bright annealing, normalizing, galvanizing, aluminizing, tinning or any other process — in the size and type best suited to your plant, process, product or production requirements. No job is too large or too unusual.

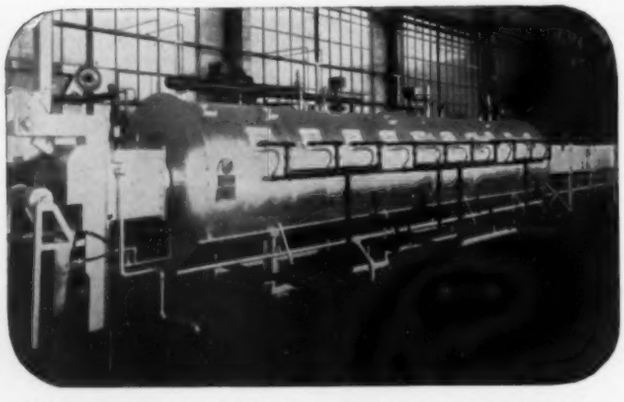
Put your production furnace problems up to experienced engineers — *it pays.*

THE ELECTRIC FURNACE CO.

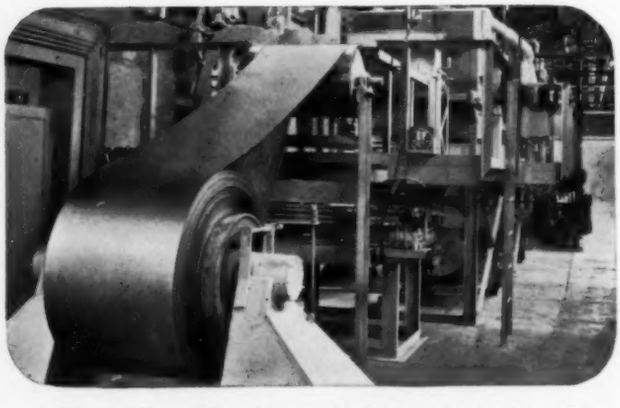
Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada



Stainless steel strip is bright or process annealed, continuously, in this EF gas fired special atmosphere tube muffle type furnace. It also handles other strip requiring lower temperatures.



An EF special atmosphere furnace with flame preheating burn-off or oxidizing section and controlled heating and cooling zones for producing various surface conditions on strip

PROOF OF LOW MAINTENANCE ON CLARK TYPE "CY" STARTERS

These unretouched photos show contact tips from a CLARK Bulletin 7707 contactor—the contactor used in the standard Bulletin 6013 size 2 AC Motor Starter — as they looked before and after a year of hard use.

The contactor is in service at Cleveland Hone and Manufacturing Company, on a special transformer and rectifier circuit used in processing automotive parts. The tips shown right above were removed from the contactor after 12 months of steady service, often operating as frequently as 5000 times per hour.

Note that slight discoloration and minute pitting are the only evidence of wear. They require no cleaning, dressing or filing, and are in condition to give many more years of dependable service.

The secret of long contact life in the CLARK Type "CY" Starter is its exclusive arc-quenching principle, using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation causes the arc to move continually on the contact surfaces, distributing the heat and preventing pitting or "build-up" at any one point. Result: extremely effective arc interruption, and greatly reduced wear on tips.

CLARK Type "CY" Starters include many more features for dependable service and reduced maintenance. Let us tell you the complete story.

Write for descriptive literature.

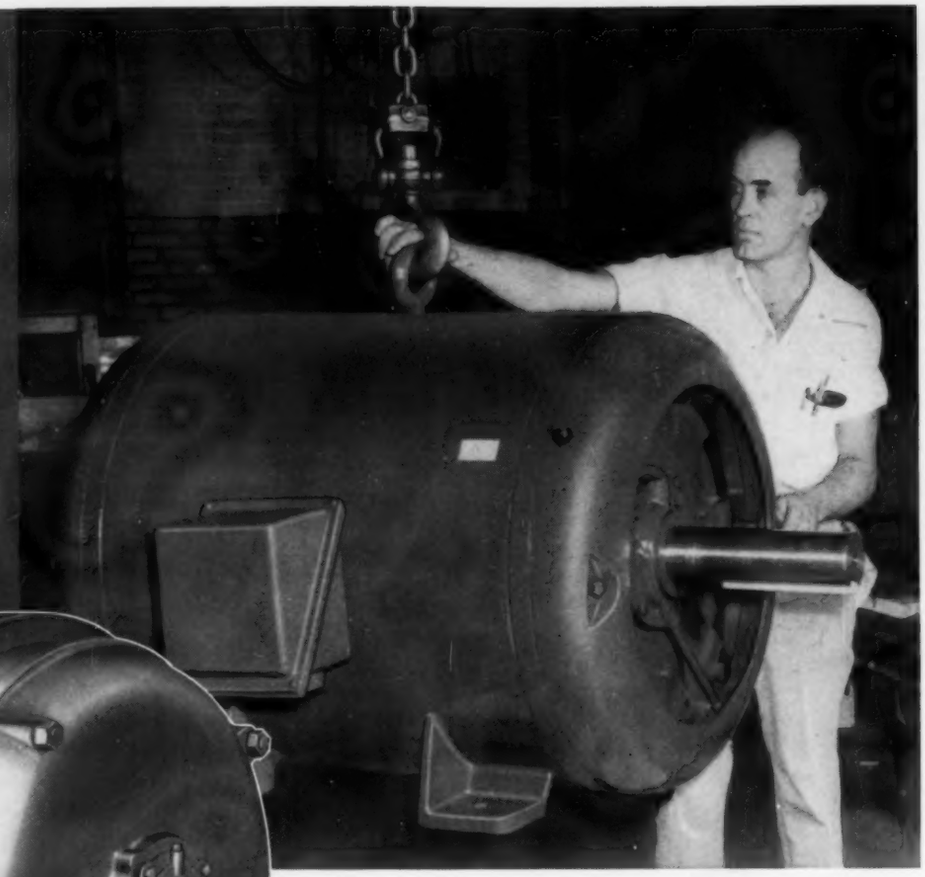
The CLARK CONTROLLER *Company*

Engineered Electrical Control

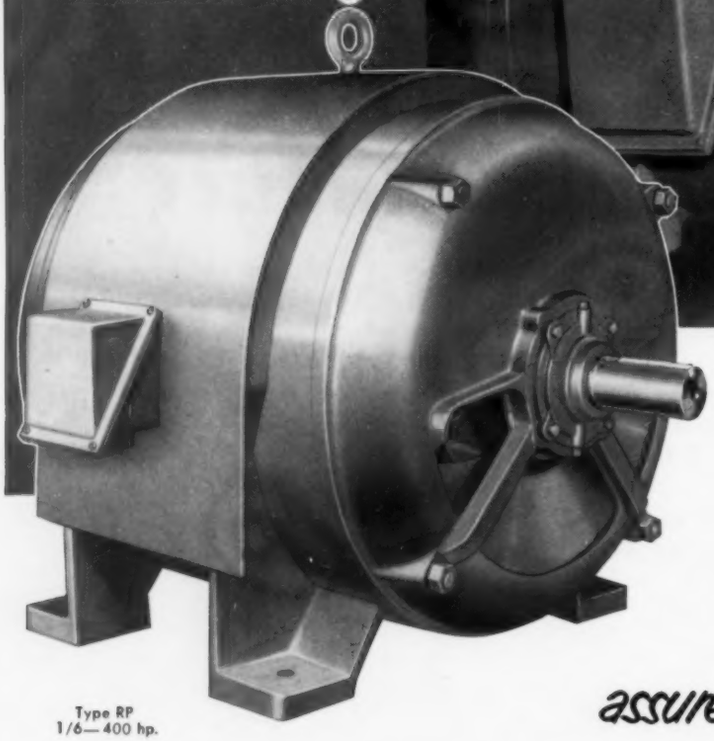
1146 East 152nd Street • • Cleveland 10, Ohio

Wagner®
ELECTRIC MOTORS
... the choice of leaders in industry

don't let production schedules lag!



Wagner totally-enclosed fan-cooled cast iron frame motor, completely protected from dust, dirt or corrosive vapors. Built in ratings from 2 to 250 hp. Also available in explosion-proof design.



Type RP
1/6—400 hp.

Wagner Industrial Motors

assure continuity of motor operation

The Wagner line of general-purpose polyphase squirrel-cage motors, built for rugged industrial service, includes a "family" of open protected-type ratings through 400 horsepower. These motors are protected by a heavy steel frame, with ventilating openings at the bottom only, and by endplates of drip-proof design.

These Wagner Motors have the winding strength and the adequate ventilation required to stand the shock of starting heavy loads repeatedly and to operate continuously without exceeding their rated 40° C temperature rise.

* * *

A skilled Wagner engineer will be glad to help you select the correct motor for *your* specific application. Just call the nearest of our 32 branch offices, or write for Bulletin MU-185 for complete information.

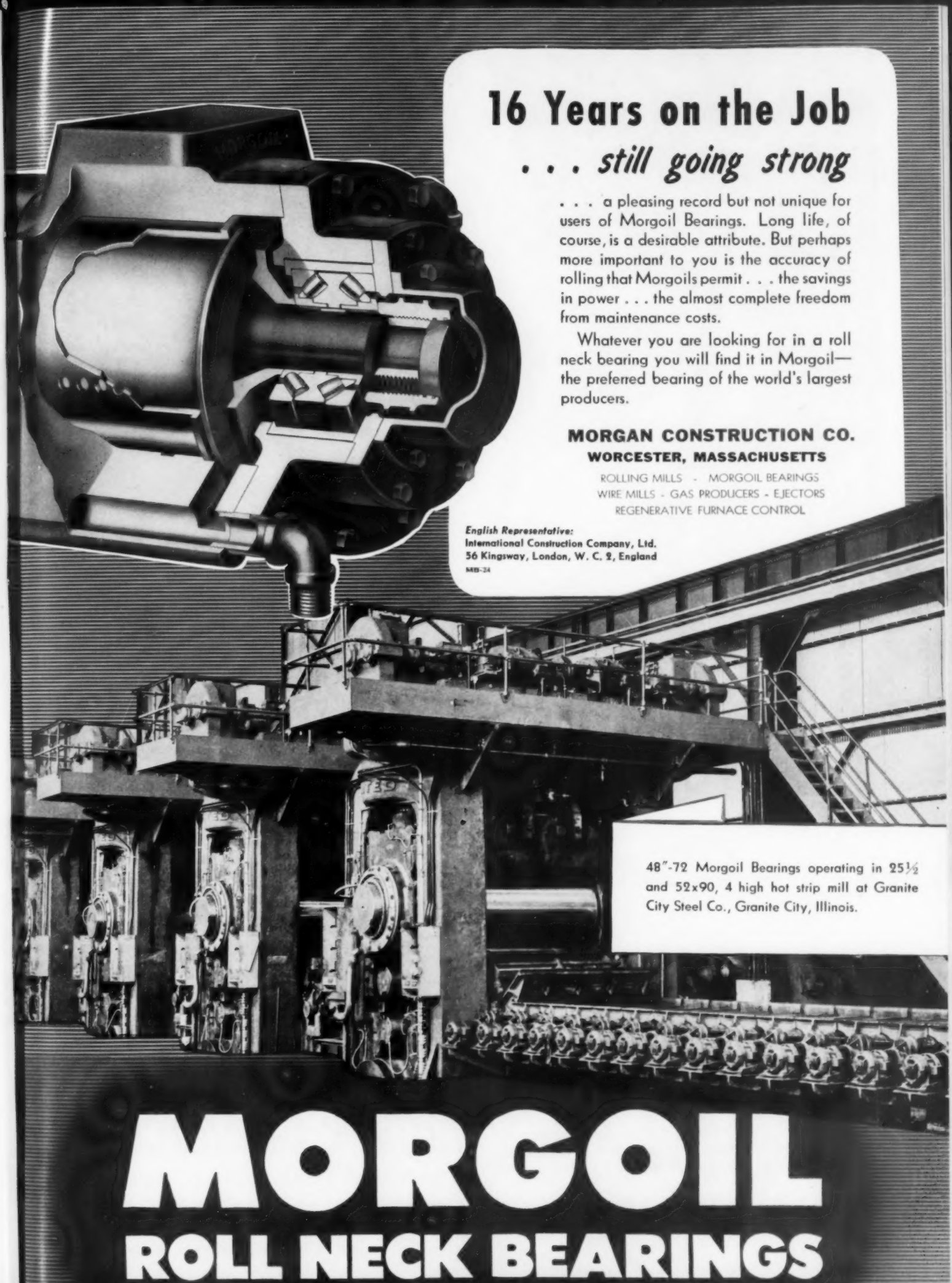
Wagner Electric Corporation
EST. WE 1891

WAGNER ELECTRIC CORPORATION
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

M54-9



16 Years on the Job

. . . *still going strong*

. . . a pleasing record but not unique for users of Morgoil Bearings. Long life, of course, is a desirable attribute. But perhaps more important to you is the accuracy of rolling that Morgoils permit . . . the savings in power . . . the almost complete freedom from maintenance costs.

Whatever you are looking for in a roll neck bearing you will find it in Morgoil—the preferred bearing of the world's largest producers.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - EJECTORS
REGENERATIVE FURNACE CONTROL

English Representative:
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MB-24

48"-72 Morgoil Bearings operating in 25½ and 52x90, 4 high hot strip mill at Granite City Steel Co., Granite City, Illinois.

MORGOIL
ROLL NECK BEARINGS

Costs less to use!

As THE industry's *highest quality* maintenance material, Permanente 84 keeps steel furnace bottoms in good operating condition with *less material* than usually required.

Thus, it actually *costs less* to use Permanente 84 than materials with a lower initial cost.

Leading steel producers report that Permanente 84, by lasting longer, helps cut down-time for maintenance and repair as much as 50%!

This means Permanente 84 makes possible more steel at lower cost per ton.

Order Permanente 84 now, and get that extra tonnage! It's your *best buy* for bottom, bank and tap hole maintenance. Also ideal for open hearth and electric furnace rebuilds.

For complete information contact *Kaiser Chemicals Division,* Kaiser Aluminum & Chemical Sales, Inc. Regional sales offices: OAKLAND 12, California, 1924 Broadway; AKRON 8, Ohio, First National Tower; CHICAGO, 518 Calumet Bldg., 5231 Hohman Ave., Hammond, Indiana.

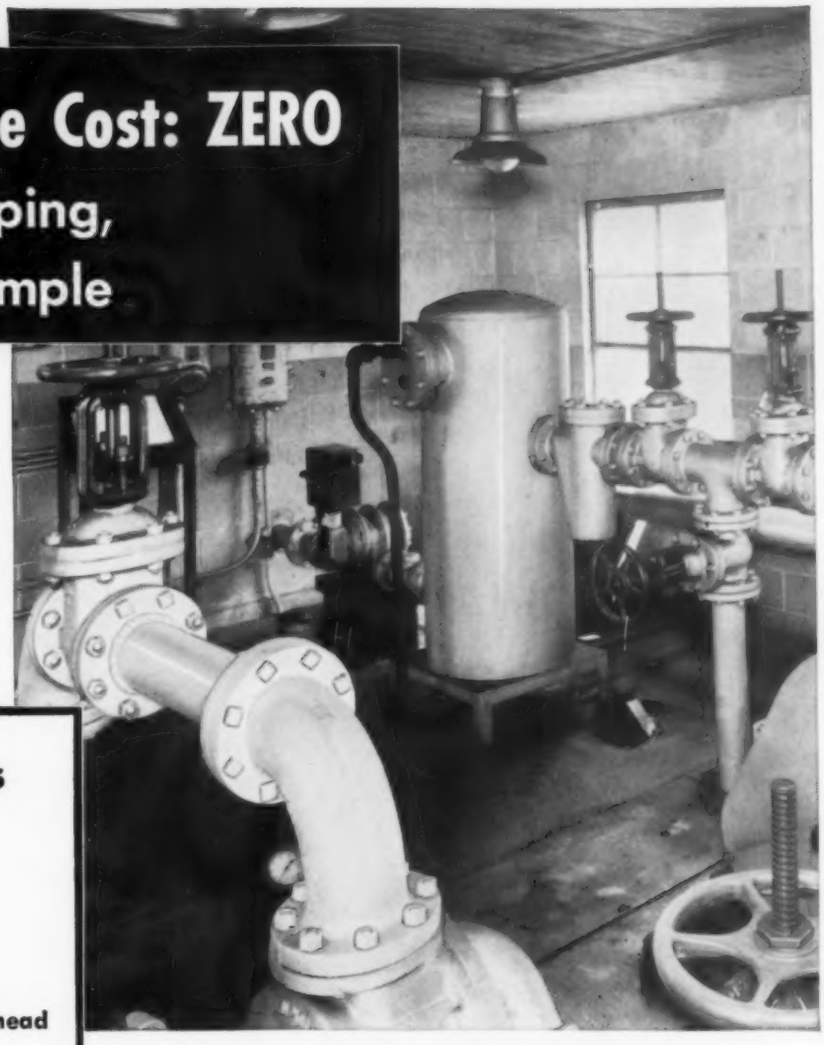
Kaiser Chemicals

Pioneers in Modern Basic Refractories

Basic Refractory Bricks and Ramming Materials • Dolomite • Magnesia • Magnesite • Alumina • Periclase

Valve Maintenance Cost: ZERO

...on fuel oil piping, for example



The Installation

At North End Yard, The Cincinnati Union Terminal Railroad, using Crane steel valves and fittings throughout diesel fuel receiving and filling system. Working pressure, 40 pounds.

Valve Service Ratings

SUITABILITY:
Doing the job as intended

FEATURES:
Exelloy seating

MAINTENANCE COST:
Zero

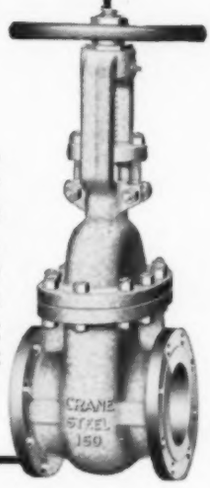
SERVICE LIFE:
Installed 1948—Shows long life ahead

OPERATING RESULTS:
Low-cost, trouble-free fueling

AVAILABILITY:
Crane catalog item—No. 47X

The Valve

150-Pound Steel Gate—with its exceptional performance assured by Crane quality design . . . by Crane pioneering skill in steel casting . . . and the high adaptability of Crane Exelloy trim for oil services. Sizes 2 to 24 in.; screwed, flanged, or welding ends. See your Crane Catalog, or ask your Crane Representative.



The Case History

Not until the terminal's engineers were convinced of its dependability and low-cost maintenance was any equipment bought for this project. Many similar systems were studied for the best means of assuring utmost economy of operation. The installation was made in 1948 . . . with welded piping where practical, using Crane materials exclusively—steel fittings, check valves, and No. 47X, 150-Pound steel gate valves.

More than 5 years later the terminal reports: Piping system operation entirely satisfactory; maintenance cost to date: zero. Further result: Crane valves have earned top consideration for proposed extension of system. The terminal knows the value of thrifty buying—quality always outweighs price-tag savings.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

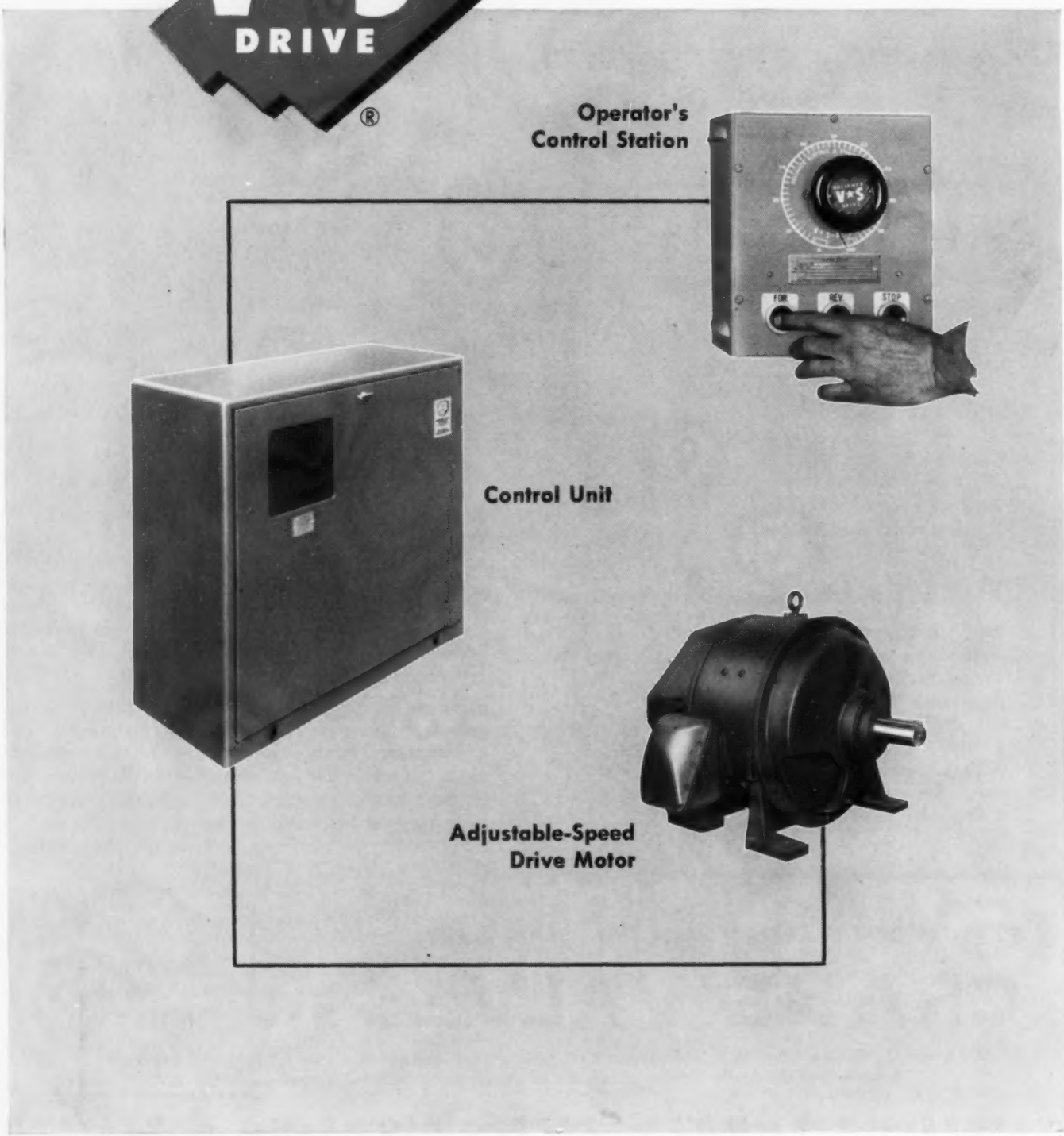
CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

BUILT AND APPLIED BY RELIANCE

THESE *Tools of Automation* INCREASE

RELIANCE V★S DRIVE ®



PRODUCTION OUTPUT IN EVERY INDUSTRY

moving things faster...more accurately!

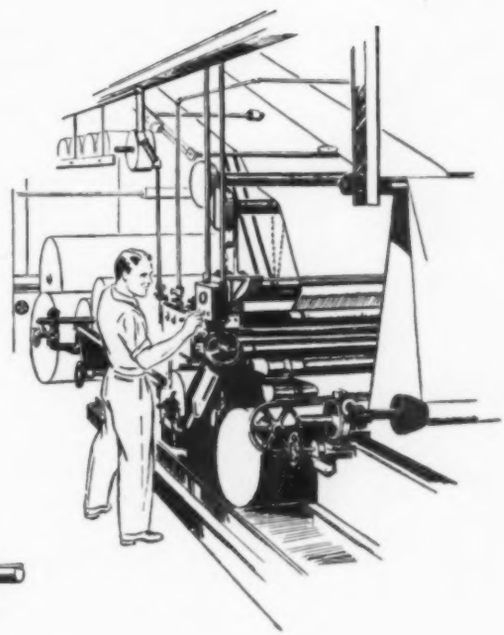
RELIANCE *Precision-Built* MOTORS

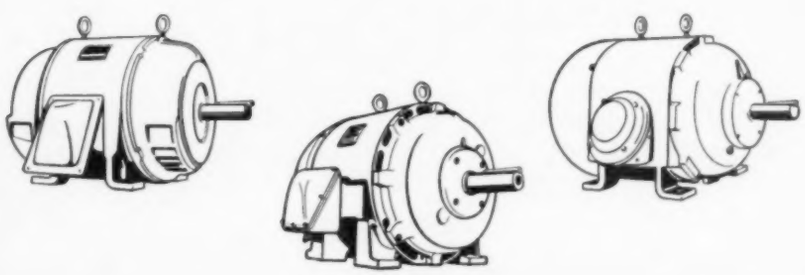
Reliance electric motors, adjustable-speed drives, electronic controls, and applied engineering—the Tools of Automation—make it possible to secure increased production in a single machine . . . part of a process . . . or an entire factory.

And these tools provide all the dependability and economy you need to get complete benefits of automated equipment. They have established an unequaled record of performance under the most exacting operating conditions in industries like textile, chemical, steel, metal working and automotive.

One of the most important Tools of Automation is Reliance Applied Engineering which is used to analyze and supply the answer to your specific situation. Reliance engineering is backed by nearly 50 years of experience in the development and engineering of drive systems which have made automation possible.

For all the facts, write for your copy of our new booklet, "The Tools of Automation". A-1474





RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops and Shorts

A report recently issued by the British Board of Trade calls attention to the AISE Convention and Iron and Steel Exposition to be held in Cleveland, Ohio, September 28, 29, 30, October 1. The report quotes a United Kingdom manufacturer who visited the 1952 Exposition as saying it was of primary importance, with manufacturers of equipment used in the production of iron and steel showing new products to a greater extent than in any other show for the past 25 years. It further quotes the British Consulate in Cleveland as saying that this show should not be missed by any representatives of United Kingdom firms interested in medium or heavy industry who might be visiting the United States at the time of the show.

How about you fellows who live closer? See you in Cleveland.

▲

THE 46-in. slabbing mill at U. S. Steel's Fairless Works set a record by rolling 425 ingots, weighing 4038 tons, into slabs in one eight-hour turn on July 27. This tops the 3785-ton turn record set at the company's Homestead Works in January of this year.

▲

THE National Fire Protection Association reports that every day there are 1087 home fires, 95 store fires, 97 factory fires, 8 church fires, 11 school fires, 4 hospital fires — and 33 deaths by fire.

Fire prevention week is schedule for October 3-9, but maybe we should make it every week.

▲

AND perhaps it might be well to mention the schoolboy who won a contest for the best answer to the question: "What are the three most common causes of fire?" His answer: "Men, women and children."

▲

A few years ago various statements appeared in the press to the effect that the break-even point in the steel industry was at 85 per cent operation. At that time we disputed the figure as one set up by people unfamiliar with the depression operations of the early thirties.

Reports for the first six months of 1954 show reasonably good earnings at 70 per cent operation. In some cases, second quarter reports are actually better than those for the first quarter. And we'll risk a small wager that the break-even point is below 50 per cent for most integrated companies, once they get into the swing of it.

AS one of our friends said: "If we hadn't expanded, we'd think we were really going to town with today's business."

▲

THE fellow next door says the nicest thing about summer is that it's always too hot to do the things we didn't do last winter because it was too cold.

▲

SPEAKING before the Institute of Food Technologists, American Can Company research men reported that "tin cans" of the future may well be tinless. Experimental work is under way on cans made of untinned steel, specially treated steel, aluminum, and steel coated with aluminum, zinc and nickel. They said that, for the foreseeable future, most of the tinless cans must be made of steel or steel coated with other metals, as no other metal is produced in sufficient quantity to meet the needs of 35,600,000,000 metal cans produced annually.

▲

THE office philospher says that it's the number of square people, not the number of square miles that makes a country great.

▲

A study by the Machinery and Allied Products Institute shows current replacement expenditures for capital equipment are $10,400,000,000 per year, and will increase to $15,000,000,000 by 1960 and to $26,700,000,000 by 1975.

▲

MAYBE we're unduly timid, but reports that passenger cars may have a top speed of 150 mph within five years remind us of the little verse:

Buses turn over, airplanes crash,
Trains are wrecked, and autos smash.
Hikers are slaughtered, ships can sink.
Better stay home is what I think.

▲

THEY say that 35,000,000 Americans stop work for coffee every morning. Wonder how many stop for a coke every afternoon.

▲

THE American Iron and Steel Institute locates the geogaphical center of the steel industry in Allen County, Ohio, about 7 miles east-north-east of Lima.

▲

MANY men of 60 look like 50, feel like 40, act like 30, and see plenty of opportunity walking along the street they overlooked at 20.

▲

MOST people's financial problems are simple. They're short of money.

▲

ACCORDING to figures released by the American Iron and Steel Institute, defense programs (including atomic energy) used about 18,000,000 tons of steel direct from steel mills in the three years 1951-1953. This represents about 8 per cent of the total steel produced.

The "inside" story of *ElectroniK* instruments

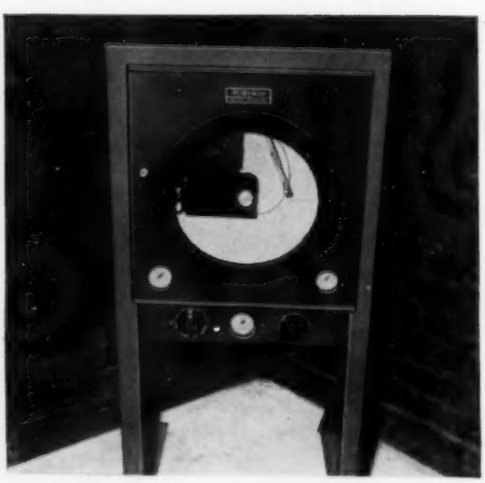
Maybe you've never seen what's inside the case of an *ElectroniK* instrument. And even if you have, you might not realize how each component has been painstakingly refined to contribute its share to the overall performance and dependability of the instrument. Three of these components in particular—the converter, "Continuous Balance" amplifier and the balancing motor—are key members of the *ElectroniK* team with which you should get acquainted.

The Converter is what transforms tiny direct-current signals from the thermocouple or other sensing element into an alternating voltage that the amplifier can conveniently handle. In principle, it is somewhat like the vibrator in your automobile radio. But because it deals with such small bits of electrical energy, it has been designed of carefully selected materials which prevent the introduction of misleading signals into the measuring system. It is hermetically sealed against the effects of dust, humidity and atmospheric pressure change, and is shielded against stray electrical and magnetic fields.

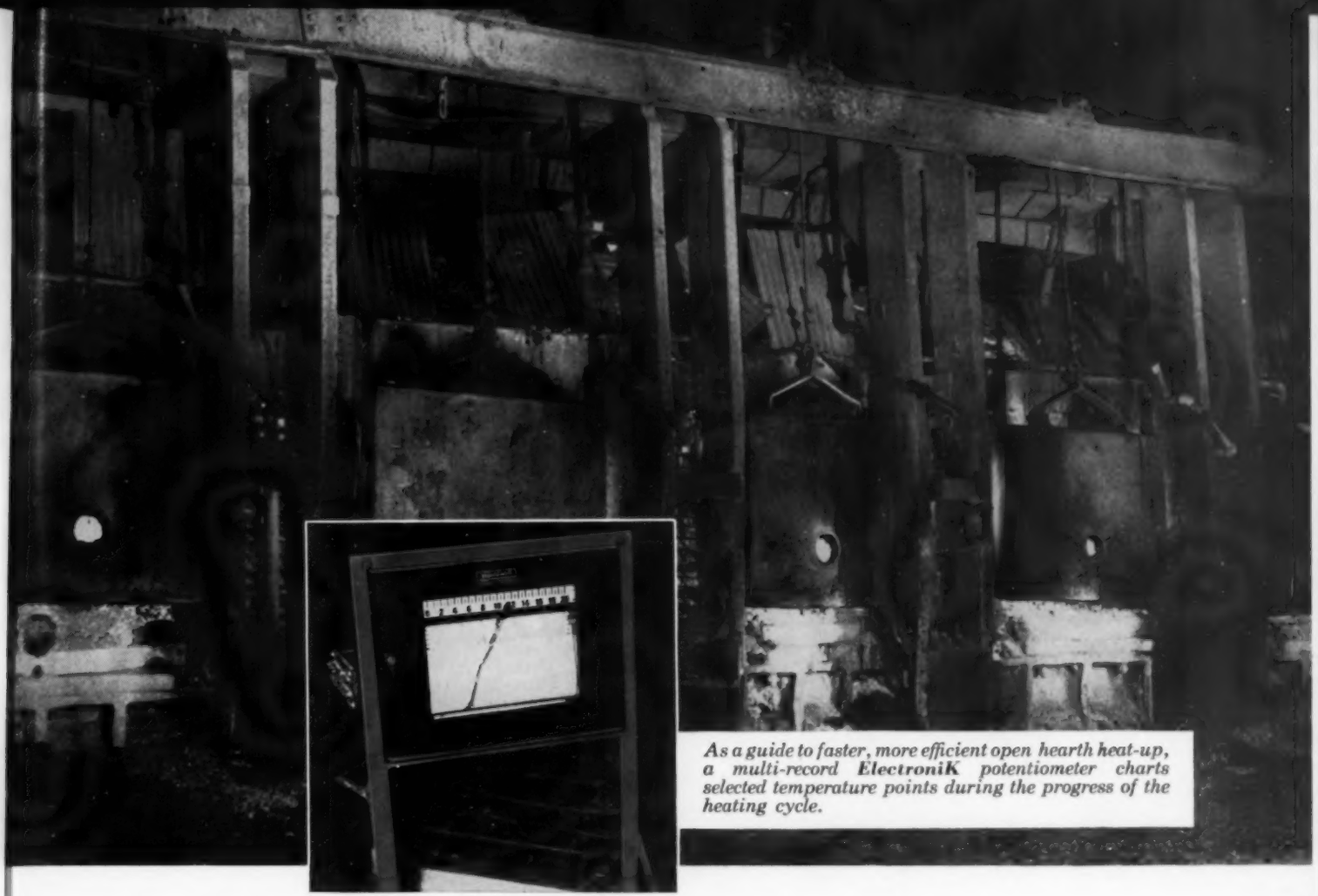
The "Continuous Balance Amplifier" boosts the incoming signals by millions of times . . . makes them strong enough to operate the balancing motor. Although it looks like part of a radio chassis, few communications circuits could equal it for quality. It uses standard, easily obtained parts, which are operated far below their normal ratings to insure exceptionally long life. The circuit has great stability against drift and pick-up, and is thoroughly temperature compensated.

The Balancing Motor does the work of moving the pointer, recording pen and any control devices that may be incorporated in the instrument. It packs plenty of power into a small space . . . gives ample torque to give fast, accurate positioning whenever the amplifier calls on it. Totally enclosed, the motor is impervious to dust, dirt and changes in mounting position.

Open hearth heat-ups speeded ...costs reduced...



For a fully automatic heat-up, a circular chart program controller regulates fuel input to bring the furnace to temperature along a specified time-temperature curve.



As a guide to faster, more efficient open hearth heat-up, a multi-record ***ElectroniK*** *potentiometer charts selected temperature points during the progress of the heating cycle.*

with ElectroniK instruments

WHENEVER an open hearth furnace is being brought back in production after repairs, the time and expense of heat-up can be substantially reduced with the help of *ElectroniK* instrumentation. In place of the old "rule of thumb" methods so widely practiced in heat-ups, these instruments provide operators with accurate data on which to base fuel adjustments. When desired, the instruments can automatically bring the furnace to temperature at a preset schedule . . . without attention by operators.

The thorough, even heating that is made possible adds substantially to the life of refractories. At the same time, rate of heating can be held at the fastest safe rate, and total time and fuel consumption during heat-up can be kept to a minimum.

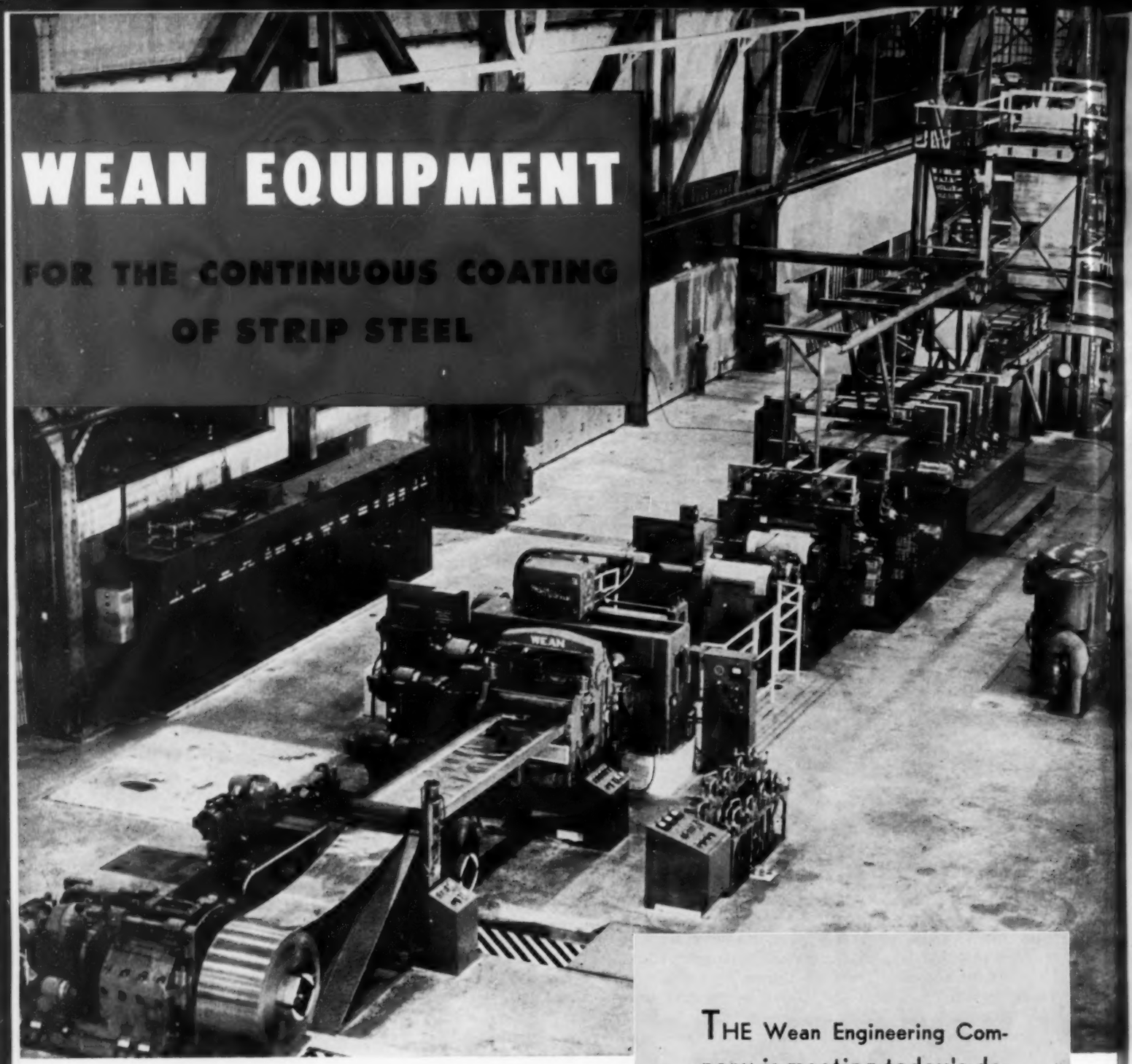
Two alternate instrument systems are available. Where manual regulation is preferred, an *ElectroniK* four-record strip chart instrument records temperatures of thermocouples in the furnace at selected locations above doors and in the roof. A special chart makes it easy to compare the heating curves with the desired time-temperature relationship, to facilitate manual adjustment of fuel. For fully automatic control, an *ElectroniK* circular chart program controller regulates fuel input to make temperature rise evenly at a prescribed number of degrees per hour. Instruments are usually mounted in a simple steel frame, to make the control system movable for transfer from furnace to furnace as needed.

Your nearby Honeywell sales engineer will be glad to discuss the system best suited to your own shop . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Data Sheet No. 6.4-11, "Faster Heat-Up for High Temperature Furnaces."**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



WEAN EQUIPMENT

FOR THE CONTINUOUS COATING OF STRIP STEEL

THE Wean Engineering Company is meeting today's demands for equipment to produce tin plate and zinc coated strip steel with light coatings by the electrolytic method; also equipment to produce chemically treated black plate and strip steel. Equipment for coating strip steel with zinc and other materials by the hot dip method is also available.

The WEAN

ENGINEERING COMPANY, Inc.

WARREN ---------- OHIO

Associate Company—Wean Equipment Corp.—Cleveland, Ohio

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P. E. THOMAS, *Assistant General Superintendent,* United States Steel Corp., Gary Steel Works, Gary, Ind.

J. N. IMEL, *Superintendent Continuous Strip and Sheet Department,* Jones and Laughlin Steel Corp., Pittsburgh, Pa.

Managing Director
T. J. ESS
Empire Building
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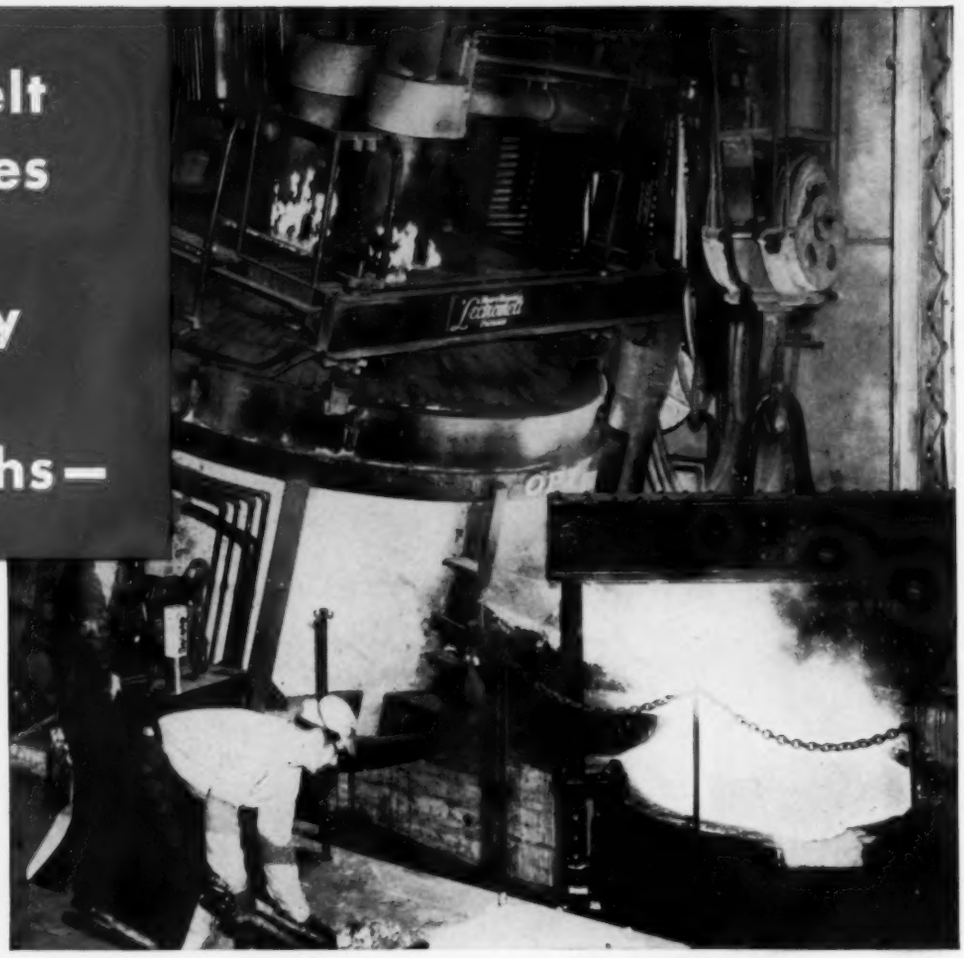

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MOORE RAPID

WHEN YOU MELT... *Lectromelt*

METALLIC RECUPERATORS in the Steel Industry

By E. A. VIEROW
Superintendent, Fuel and Power Dept.
Youngstown Sheet and Tube Co.
Youngstown, Ohio

. . . . metallic recuperators offer fuel economy and increased production . . . .

▲ THE recuperator was invented by James B. Neilson in 1828. It is generally defined as a continuous heat exchanger in which part of the sensible heat in hot products of combustion is transferred in unidirection through separating walls or partitions to incoming combustion air or gas. It is interesting to note that the first recuperator some 125 years ago was a metallic unit for preheating air for blast furnaces. This and other similar cast iron tube recuperators were used for some 30 years before Cowper invented the refractory regenerative type hot blast stove to meet the need for higher blast temperatures, impractical with metals available for recuperators at the time. Abroad, metallic recuperators are again being installed in blast furnaces up to 300 tons per day capacity and are being talked about for larger units.

The objective in the development and application of recuperators for steel heating and reheating furnaces was to overcome many disadvantages experienced in adapting Siemen's regenerators. Stated affirmatively, recuperators being continuous in operation, give more uniform preheat, require less space, eliminate the necessity of reversing valves and, what is very important, they make possible the independent design and location of burners and waste gas ports needed for ideal furnace operation.

Early interest and developments in recuperators were confined almost entirely to Europe where scarcity and quality of fuels necessitated consideration of some form of waste heat recovery through air or air and gas preheat on most furnaces, not only for the sake of fuel economy, but in order to provide adequate heat for satisfactory heating. Refractory recuperators began to appear about 1900 and metallic recuperators about 1920. It is understood that in the European steel industry today, most heating furnaces, regardless of size, are equipped with recuperators. It is reported that except for soaking pits and similar furnaces, metallic recuperators of various makes and kinds are exclusively used.

In the United States interest in recuperators for heating furnace operations began about 25 years ago as fuel became a more important cost item. The refractory recuperators of this early period were not considered a success. The metallic recuperators were an acknowledged failure. This can be attributed in both instances to lack of experience in design, poor engineering of applications, dependency on the human element for furnace operation and recuperator protection, and general lack of attention. Poor quality of available heat and corrosion resisting metals was an added factor in the case of metallic recuperators. Although an interest was maintained in refractory recuperators, this initial discouraging experience killed any really active consideration of metallic recuperators in this country for many years to come.

REFRACTORY RECUPERATORS

Considerable improvement was made in the design and construction of refractory recuperators for reduced leakage and increased durability. In an effort to further offset the inherent weaknesses of the refractory recuperator, two different applications were developed.

In one type of application, for soaking pits and similar furnaces, where the burner ports and waste gas outlets are more or less closely located and burner port design is not so critical, the recuperator is placed below and built as an integral part of the furnace. In this arrangement, pressure differences between air and waste gas ducts in the recuperator are small even when

air is supplied under slight pressure. Leakage, if it does occur, is toward the waste gas side where a considerable amount can be tolerated without materially affecting furnace operation. In this design there is practically no loss in waste gas temperature to the recuperator or drop of preheated air temperature to the burners. Preheated air temperature is high, varying from 1300 to 1700 F depending on the type of fuel used. The use of automatic temperature, combustion and pressure controls, plus a little attention to operation and maintenance, have made this type of refractory recuperator installation a success with respect to production as well as fuel economy.

In the second type of refractory recuperator application, for continuous furnaces and the like, where burner ports and waste gas flues are widely separated and where furnace operation requires more exacting burner design, the recuperator is located remotely and a hot air fan is used to pull the air through the recuperator. This type of installation is also applied to soaking pits where recuperators cannot be located as previously described. The use of a hot air fan makes possible the delivery of preheated air to the burners at somewhat higher pressures than is practical on account of excessive air leakage when using a cold air fan with a refractory recuperator. Preheated air temperature normally varies between 400 and 850 F. However, with this arrangement perfect equalization of pressure in the air and waste gas ducts of the recuperator does not prevail at all rates of firing, with the result that at times waste gas is sucked into the combustion air. This not only adversely affects fuel economy, but in many cases also acts to reduce furnace heating capacity. On this account there has been a growing dissatisfaction with this type of refractory recuperator installation. The metallic recuperators installed in this country so far have demonstrated their superiority in this respect and also from the standpoint of raising preheated air temperatures from the 400 to 850 F range to the 650 to 1000 F range.

METALLIC RECUPERATORS

The first installation of a modern metallic recuperator in heating furnace operations in the American steel industry was made on a continuous buttweld furnace in 1938. This was a departure from the use of the refractory recuperator with hot air fan on this type of furnace. It was so successful that a metallic recuperator has been standard for new continuous buttweld furnaces ever since, and the trend is toward replacement of refractory recuperators on older installations. Waste gas leaves this furnace at temperatures up to 2800 F and is tempered to 1800 F before entering the recuperator. The waste gas is under pressure in the recuperator. It is also laden with iron oxide. Air is preheated to temperatures up to 1000 F.

The successful making of continuous buttweld pipe involves a most exacting job of high speed heating of fast moving continuous skelp. This requires correct burner design for quick fuel-air mixing, accurate metering of air to fuel for close control of flame quality, and uncontaminated preheated air for the development of high flame temperatures. The refractory recuperator for reasons previously given is seriously handicapped in trying to meet these specifications. In contrast, the modern metallic recuperator provides an adequate supply of unadulterated preheated air, it makes possible good metering of air to gas, and it delivers the air to the burners at the pressure desired. It is not surprising therefore that the prodding influence for the use of the metallic recuperators in continuous buttweld furnaces was the possibility for increased production and better quality heating rather than fuel economy.

This possibility for increased production has also been a motivating force in recent installations of metallic recuperators on hot strip mill slab heating furnaces, some of which involved replacements of refractory recuperators. Most furnaces of this type, equipped with refractory recuperators, sooner or later develop critical bottlenecks in air supply and stack draft, with resultant loss of production. On the other hand, according to reports the performance of those furnaces equipped with metallic recuperators are even exceeding the expectations with regard to production.

The failure of metallic recuperators in this country some twenty to twenty-five years ago can as previously stated be blamed on lack of experience in design, inadequate materials of construction, dependency on the human element for furnace operation and recuperator protection, and to general lack of attention. Today metallic recuperator designs have been proven, suitable metals are available, automatic furnace temperature and combustion controls are used, automatic recuperator safeguards are incorporated, and it is generally realized that a little periodic maintenance is necessary and worth while. The conditions under which a recuperator must operate on a continuous buttweld furnace are much more severe and hazardous than those usually encountered in heating furnace operations. It is surprising to learn that metallic recuperators have also proven less costly to maintain than refractory recuperators, even in the case of the continuous buttweld furnace.

At present two metallic recuperators are being commercially marketed in the United States for use in heating furnace operations in the steel industry. Various claims are made for each design. This paper is not particularly concerned with such claims, but rather with the fact that proven recuperators are commercially available in this country, and that they are well worth considering.

THE THERMAL TRANSFER RECUPERATOR

The Thermal Transfer cast metallic recuperator originated in Europe some twenty years ago and today is extensively used abroad. It was first introduced in this country on a continuous buttweld furnace in 1938 and has been virtually standard for this application ever since. There are now in the United States and Canada some 27 different kinds of steel mill furnaces equipped with a total of 51 recuperators of this type.

Figure 1 gives a vertical flue type arrangement of this recuperator. The waste gas is shown as flowing upward through the unit and the cold air as entering in the top section. The direction of flow of air and waste gas is in some cases reversed. This unit may be placed adjacent or above or below the furnace to suit local conditions. It is serviced or repaired in position.

Figure 2 shows a horizontal flue type arrangement of the same recuperator. This so-called "packaged unit" may be installed in any horizontal flue between the furance and stack above or below ground level. In this case no additional housing or lining is required. This unit is readily removed by overhead crane for servicing or repairing.

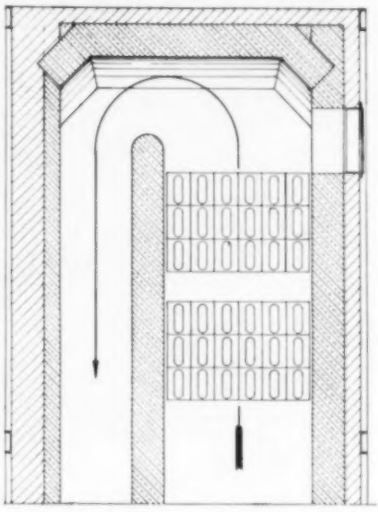
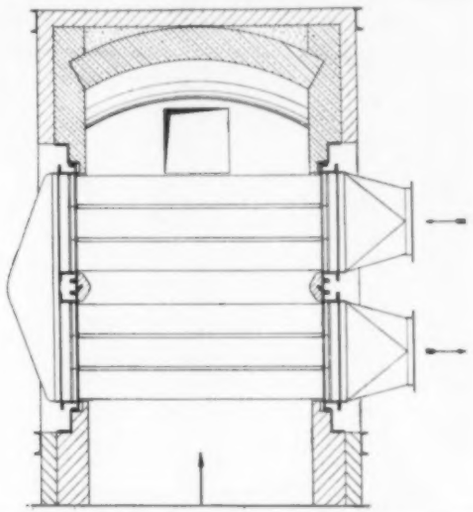


Figure 1 — In the vertical flue type arrangement, the waste gas flows upward through the unit and cold air enters into the top section.



In Figure 3 is shown a typical two-pass, air flow unit or assembly of this recuperator. Erected in the position illustrated, it is the horizontal flue type recuperator of Figure 2. Installed on its side it is the vertical flue type recuperator of Figure 1. It is observed that the two-pass assembly consists of two banks of heating elements in series. The number of banks used, the number of elements in a bank and the length of elements are varied to meet the specific requirements of each installation.

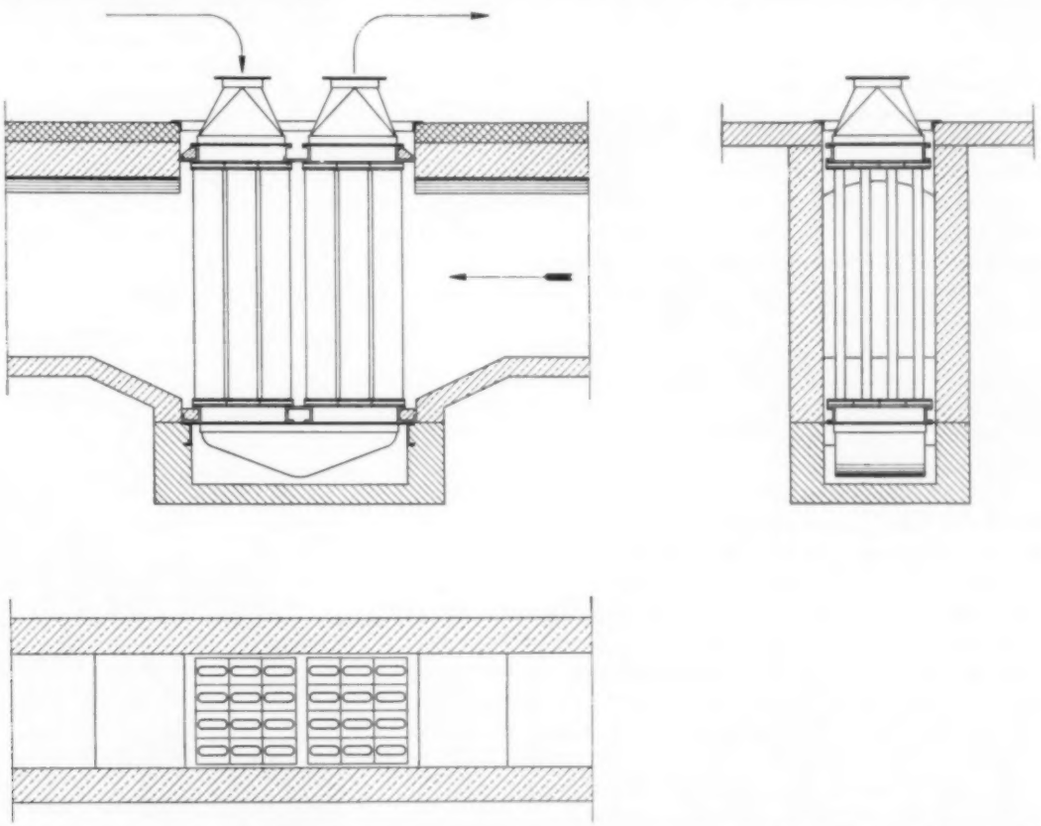


Figure 2 — This horizontal flue type arrangement is set up as a packaged unit.

This recuperator is built up of thin wall cast metallic elements. Heat resistant cast iron or cast alloy steel or a combination of both, are used, depending upon the conditions of operation. The three specifications generally used are: 1.0/1.15 chrome composition for waste gas up to 1500 F correlated with air delivery up to 800 F; grade 20/22 chrome for waste gas temperatures up to 1800 F with air temperatures to 1000 F; and a 28/30 chrome for waste gas temperatures to 1900 F with air preheat to 1350 F. The builder claims castings are best suited to withstand the temperature and corrosive conditions required of most recuperator applications and on this account give longer life and better service.

A group of elements are interlocked with one another and encased in a binding frame to form a bank. The elements in each bank are sealed with asbestos and

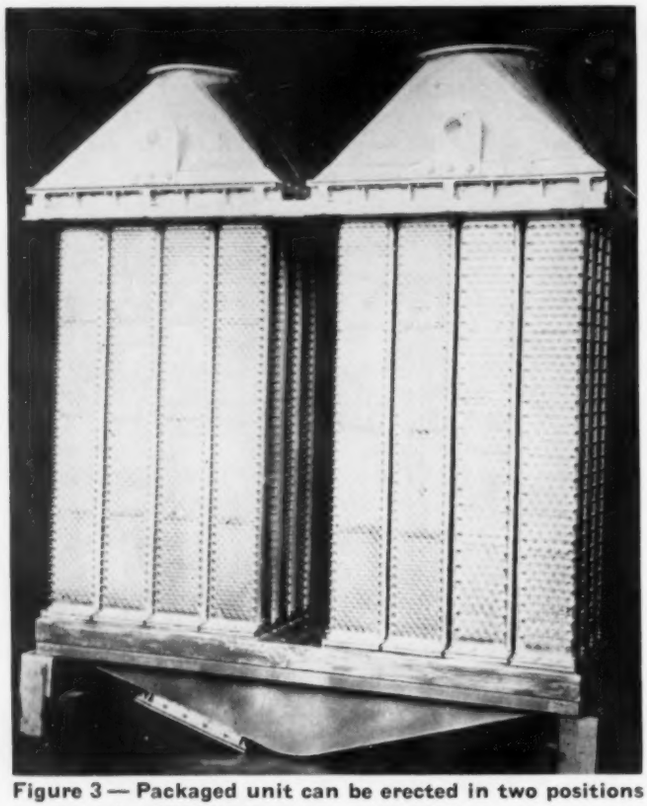


Figure 3 — Packaged unit can be erected in two positions to either give horizontal or vertical flues.

retort cement, and bolted together at the ends with mechanical tolerances which provide for the relatively small differences of expansion of individual elements in the same bank. Each bank of elements is likewise elastically bound at its ends in cast frames. The return U-bend ducts between banks of elements in series, as well as the cold air inlet box and the preheated air outlet box, are tightly sealed and rigidly bolted to the cast binding frames. Overall expansion is reportedly no problem because the casting bound banks of elements are free to float and expansion is absorbed and balanced by movement of the return U-bend ducts and a simple V-type joint in the preheated air outlet duct from the recuperator. It is claimed by the builder that this recuperator is to all intents and purposes leakproof, and that the best testimony is its successful use for many years in processes requiring pressure to about 7 psi which also involve explosive gases.

The different types of elements used are shown in Figure 4. The basic principle of design of these elements is the enlargement of outside and inside heating surface by the addition of cast-on streamlined needles, or fins, or other projections for increased heat transfer. This results not only because of enlargement of surface, but also on account of increased turbulence of waste gas flow and air flow. The builder credits long recuperator life to the high heat transfer rates which result in relatively lower temperatures of the thin-wall castings. It is also claimed that units of this design require a minimum of weight, space, air pressure drop and draft loss for a given recuperator capacity.

Referring again to Figure 4, elements of the (a), (b) and (d) designs have needles on both the inward and outward heat exchange surfaces. Specifically, design (a) is provided with a small inter-pitch for clean waste gas and gives maximum heat transfer efficiency per cu ft of

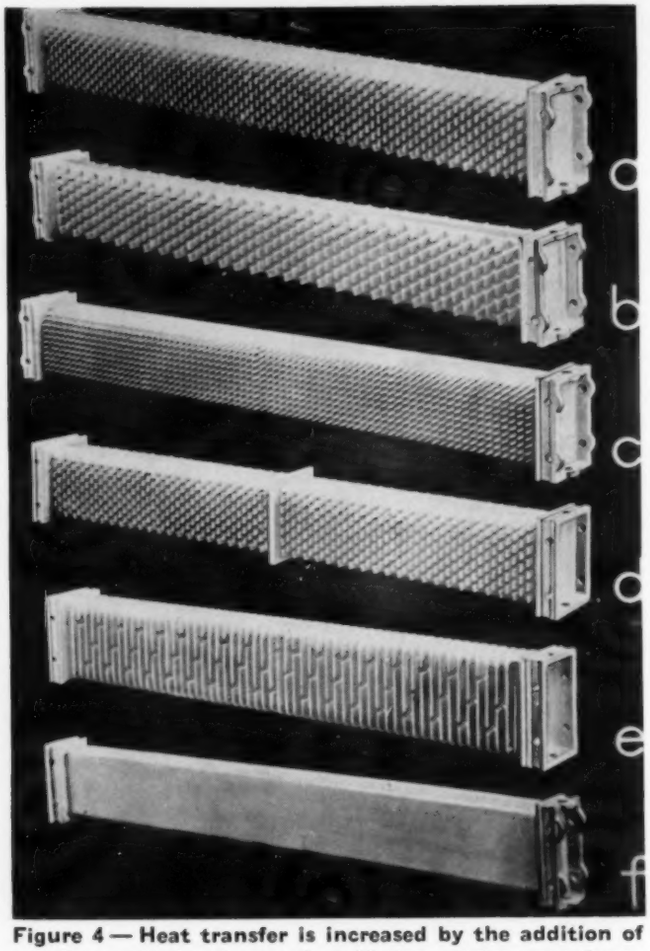
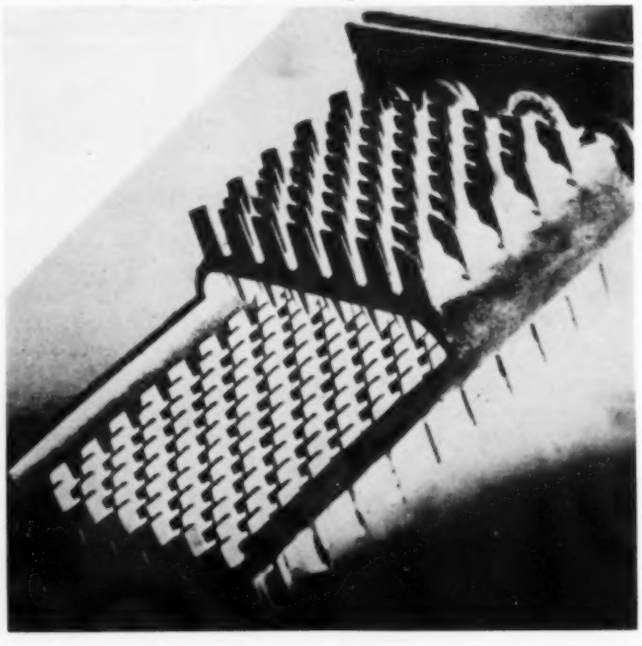


Figure 4 — Heat transfer is increased by the addition of fins to the heating surface. Various designs are shown in this illustration.

overall recuperator space. Design (b) is constructed with a wider needle pitch on the outside surface for the utilization of dirty waste gas or for high waste gas temperatures. Design (c) is outwardly fitted with conical needles for the axial flow of waste gas. Design (d) is supplied with cast-on guiding or supporting flanges for

Figure 5 — Fin design shown here gives excellent efficiency with relatively clean waste gases.



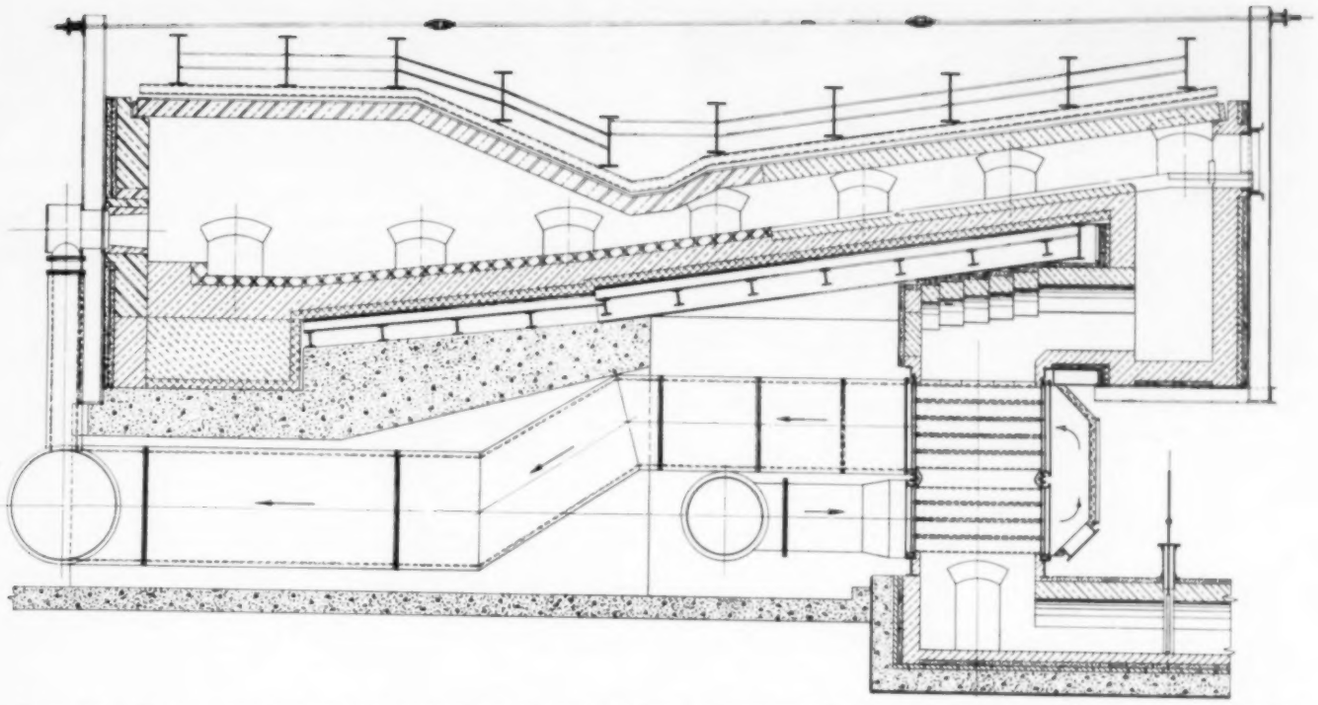


Figure 6 — Design drawing shows application of vertical type recuperator below a continuous billet heating furnace.

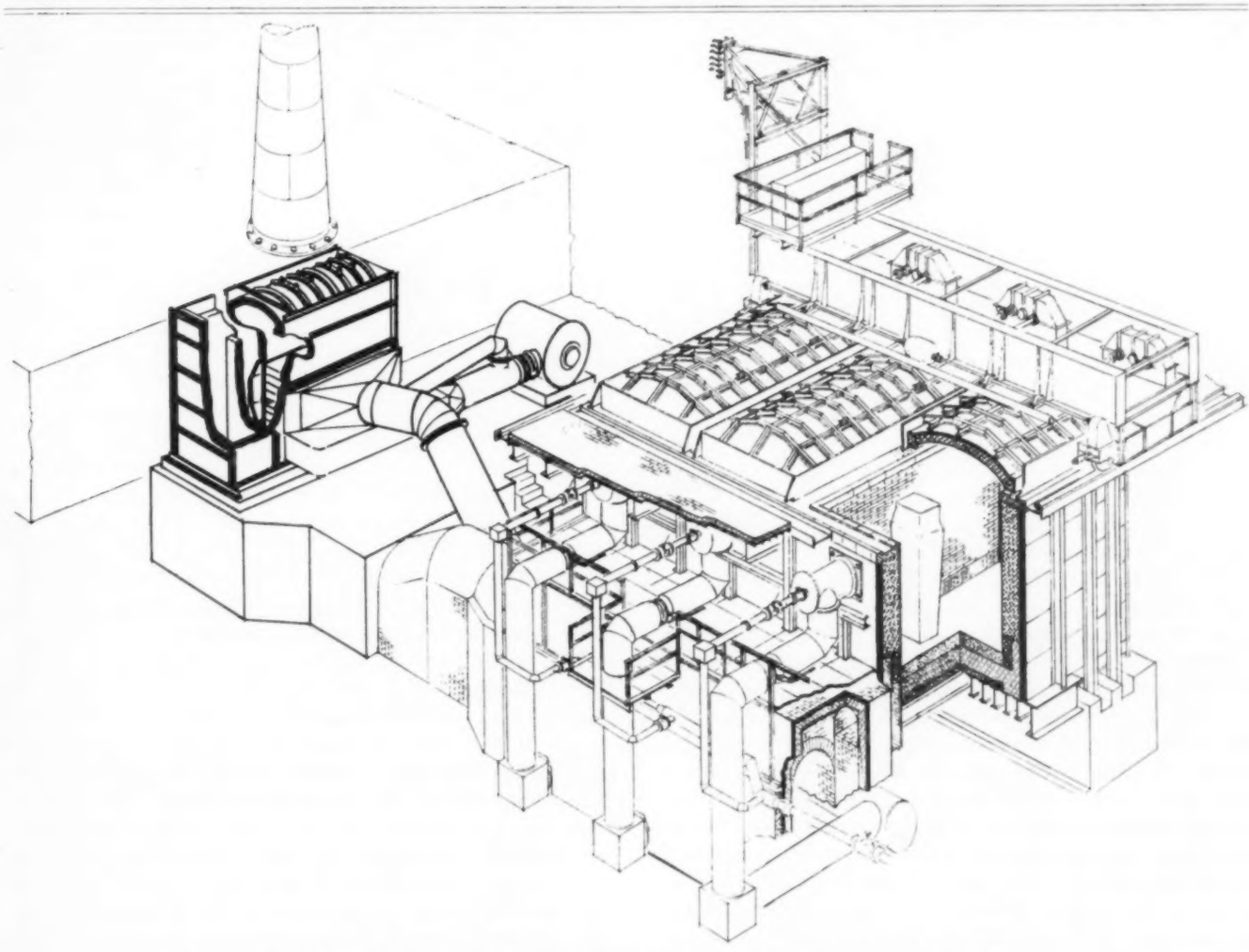


Figure 7 — Vertical flue recuperator has also been used with soaking pits.

long elements and high waste gas temperatures. Design (e) has a finned type element supplied in various pitches for utilization of very dirty waste gas. Design (f) has outside smooth surface elements with inside needle surfaces for use in excessively high temperature waste gas or for utilization of badly contaminated waste gas.

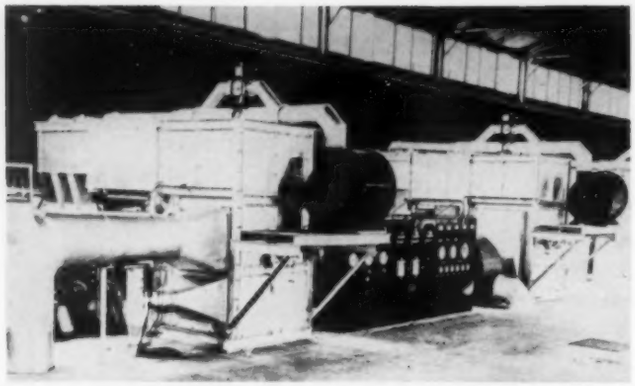


Figure 8 — Metallic recuperators have given excellent efficiency on continuous butt weld furnaces.

preheated air temperatures to about 1000 F. In Europe where various designs and combinations of elements are used, it is claimed that this recuperator is being operated with entering waste gas temperatures up to 1900 F and outgoing preheated air temperatures up to 1350 F.

All parts of this recuperator, as previously described, are joined by bolts and any single element may be replaced in a relatively short time. In the vertical flue type recuperator this is done with the unit in position. The air ducts at the ends of the particular bank involved are first removed to provide access to the element. The bolts are then removed from the element to be replaced and from any element resting on top of it in the same bank. Next the frame casting on top of the loose elements is removed and any top elements lifted and blocked. The damaged element is then pulled out.

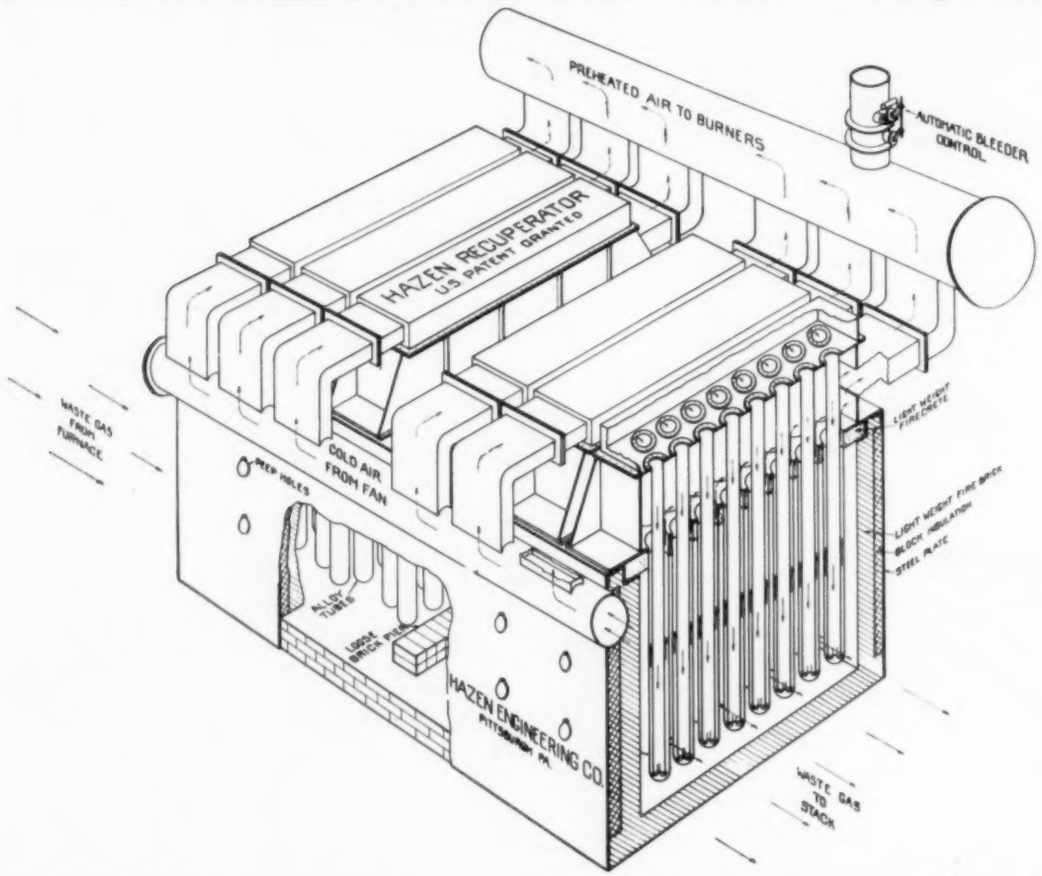


Figure 9 — In this metallic recuperator, design tubes are suspended from the top and thus are free to expand independently from each other.

A cross section of the design (a) element provided with inside and outside drop needles arranged for relatively clean waste gas and giving maximum heat transfer efficiency is shown in Figure 5. In comparison, the design (f) element is the same in cross section on the inside, but the outward surface is made smooth for excessively high temperature or badly contaminated, high temperature waste gas where heat transfer to the elements would otherwise be excessive and maintenance a problem. On this account it is also used in recuperator shock units ahead of the recuperator in waste gas temperatures up to 2200 F. In these units the temperature of the waste gas is depressed to the safe limit for the recuperator by preheating a part of the air from cold at this point.

Design (a) element has been exclusively used to date in building this recuperator in the United States and Canada with waste gas temperatures to 1800 F, and

Except for the necessary renewal of seals on the loosened elements, the job of installing the new element and getting the recuperator ready for service involves reversing the procedure. The procedure is the same with the horizontal type flue recuperator except that the complete unit is first removed by overhead crane and placed in horizontal position in the floor where convenience makes renewal somewhat easier. Handling of the elements is relatively easy as they range from three to seven feet in length and 100 to 220 lb in weight.

Figure 6 shows the application of a vertical flue type recuperator below a continuous billet heating furnace. Similar installations are also in use on slab heating furnaces.

In Figure 7 is given an isometric view of this recuperator installed in connection with a battery of soaking pits. This appears to offer a solution in cases where increased soaking pit capacity is required and existing

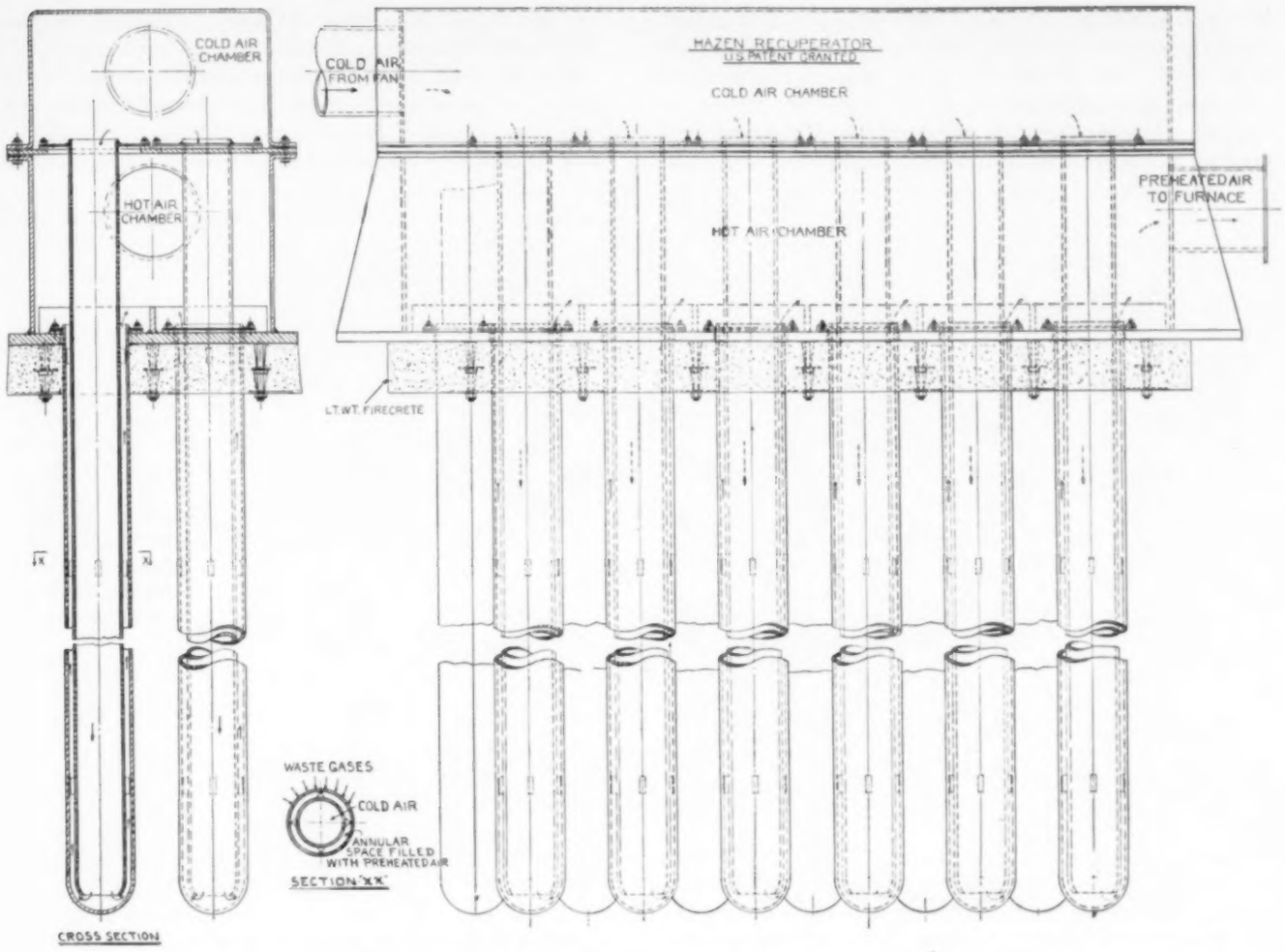


Figure 10 — Detailed arrangement of how tubes are hung are illustrated in this sketch.

space limitations make the use of a high temperature refractory recuperator adjacent each pit impractical.

Figure 8 is a side view of this recuperator applied to a continuous buttweld furnace. There are three to five units spaced along each furnace depending on length. As previously described, waste gas leaves this furnace at temperatures up to about 2800 F and is tempered to about 1800 F by the admixture of blown air in the recuperator cross-over flue. This is done by automatic temperature control. The outstanding results obtained by the use of metallic recuperators on continuous buttweld furnaces were previously discussed in detail.

THE HAZEN RECUPERATOR

The Hazen tubular metallic recuperator is of American origin and was first installed in 1943 on a billet heating furnace. There are now some 97 units installed on various types of steel mill furnaces in the United States.

Figure 9 shows an isometric assembly of the heating elements and header boxes of this recuperator. The recuperator flue can be placed to suit local conditions. The header boxes are located above the flue. The heating elements suspended from the boxes are staggered so that the flue gases are carried around the tubes in a turbulent manner. Discharge from a cold air fan is connected to the inlet air compartment of the header boxes. There are no joints exposed to hot gases.

The heating elements consist of inner and outer tubes, which are usually made from stainless steel sheets but the outer tubes, if conditions warrant, may be cast of heat and corrosion resistant steel. Outer and inner tubes are bolted to the lower and upper compartments of the boxes and sealed by means of asbestos gaskets. Air is discharged through these inner tubes, returning through the annular space formed by the outer tube into the lower or hot air compartment of the boxes. Both outer and inner tubes are suspended from the top only and are free to expand independently of each other, regardless of the existing temperature differences. This elimination of expansion problems is credited by the builder as making possible a leak proof recuperator, permitting the use of high forced air velocities required for rapid heat transfer.

Figure 10 shows the side view of one header box, in this case containing 12 heating elements, and also a cross section of the box. Section "XX" shows a cross section of an inner and outer tube. The inner tube has spacers to insure a definite annular space through which air is forced at high velocities. The circular ring or annulus formed by the inner and outer tubes, through which a thin layer of air passes at high velocity is the means of creating rapid heat transfer from the outside tube into the air. The inner tube also serves as secondary

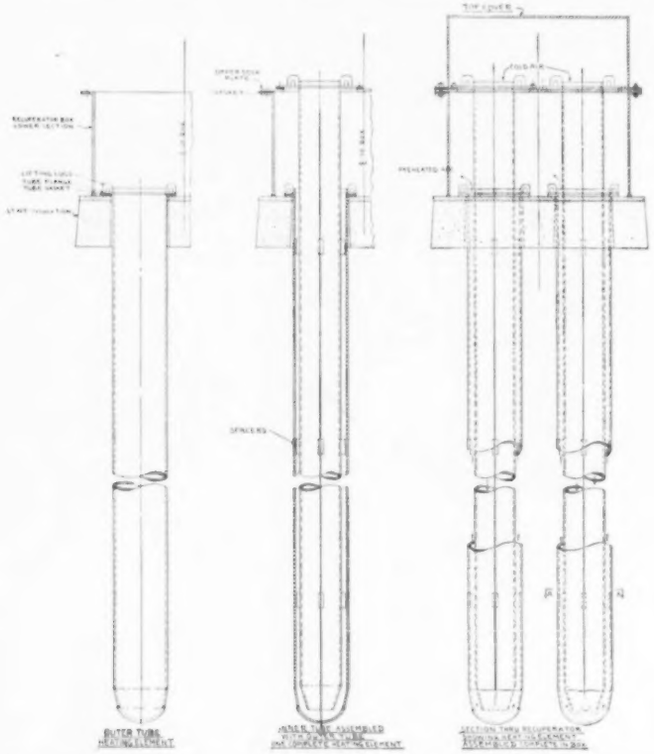
heat-transmitting surface, absorbing heat by radiation from the outer tube and giving it up to the air stream both inside and outside the inner tube. As a result of the rapid heat transfer, the metal of the outer tubes is kept at a low temperature compared with the temperature of the surrounding flue gas. On this account the builder claims long tube life is possible even with waste gas entering the recuperator at 2200 F and air leaving the recuperator at 1000 F.

One of the important claims made by the builder of this recuperator besides that of performance, is the ability to maintain it and keep it in service. Any row of elements, or any individual element (inner or outer tube) may be replaced. A study of Figure 11 shows that replacement is simple and can usually be made without moving the header boxes from their location in the flue. Individual tubes are relatively light, weight varying from 70 to 140 lb.

Referring again to Figure 9 it is observed that the first rows of elements are subjected to the most severe service, due to the fact that they must withstand not only the temperature of the flue gases, but also the reflected heat from the brickwork of the flue at this point. A higher pressure drop of the air therefore is used through this section of tubes, with the object of keeping the tube temperature well below the critical oxidizing temperature of the metal used.

In order to protect against overheating tubes because of insufficient air flow, this recuperator is equipped with an emergency bleeder in the hot air duct between the recuperator and the burners. This bleeder opens automatically to the atmosphere when necessary to increase the air flow to limit the hot air temperature to the safe maximum for which the particular unit is designed. As a further precaution this bleeder also operates to assure a sufficient air flow rate through the recuperator at all times to prevent possible tube damage because of radiation from adjacent brickwork in cases of irregular furnace operation.

Figure 12 shows a plan view of this recuperator installed adjacent to a furnace. The recuperator flue may be either above or below ground level, and in either case is readily accessible for servicing and inspection.



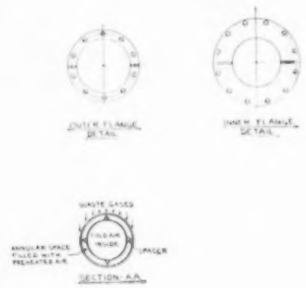


Figure 11 — Replacement can usually be made without moving header boxes.

Figure 13 shows the recuperator as proposed for use beneath a furnace where low overhead clearance limits the installation and removal of recuperator tubes. Header boxes equipped with wheels and assembled on removable rails are shown at the side of the furnace, where the tubes are installed. A complete unit of box and tubes is rolled in place under the furnace at one time. One side of the recuperator flue is made up of removable sectional bulkheads between each vertical column. These encase the recuperator units after they are in place underneath the furnace, and when a bulkhead is removed the respective recuperator unit may be rolled out from under the furnace for accessibility for cleaning or replacement.

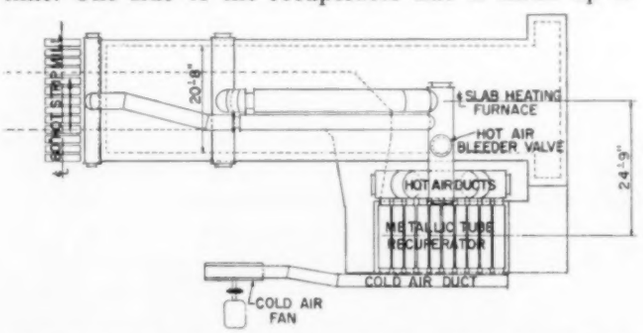


Figure 12 — Recuperator flues may be either above or below ground level. Unit shown is installed on an 80-in. hot strip mill slab heating furnace.

Figure 14 shows the recuperator installed above a slab heating furnace. In this arrangement the waste gas

is taken away from the furnace, passed through the recuperator and delivered to the stack in the simplest possible manner. On new installations this means considerable savings in furnace construction cost. In the case of existing furnaces, installations above the furnace may usually be applied with a minimum of outage time because most of the work can be done preliminary to the final change over. Walkways make for convenient inspection and cleaning. Finally, according to the builder, less draft is required with this recuperator arrangement, or conversely more effective draft is available for the furnace. In many existing furnaces equipped with refractory recuperators, lack of adequate air supply and sufficient and proper waste gas exhaust are the obstacles to production. It is reported that furnaces of this type converted in the manner described have given increased furnace heating capacity amounting to 20 per cent.

Figure 15 gives a view looking down on the header boxes of recuperators installed above several furnaces. The emergency air bleeder stacks are shown adjacent each furnace.

Figure 16 shows the structural arrangement of the recuperator above the furnace. The entire recuperator unit and stack is supported by separate steel work or by extending the furnace buckstays.

Figure 17 shows an outside view of the recuperator installed above a furnace with a small crane attached to the lower cord of the building trusses. The latter is proposed where space limits the installation and removal of recuperator tubes because of low elevation of the building trusses. In this case, one side of the recuperator flue is designed in a manner similar to that shown in Figure 13 where the recuperator is located under the furnace.

It is interesting to note that this recuperator is used in quite a number of soaking pit installations in this country wherein the flue gases from a battery of pits

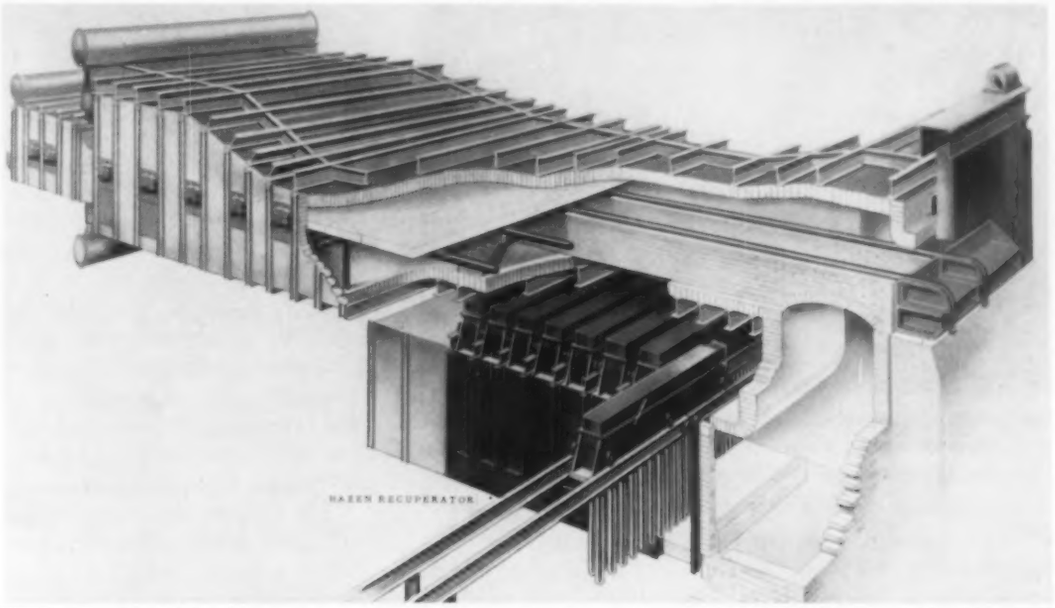
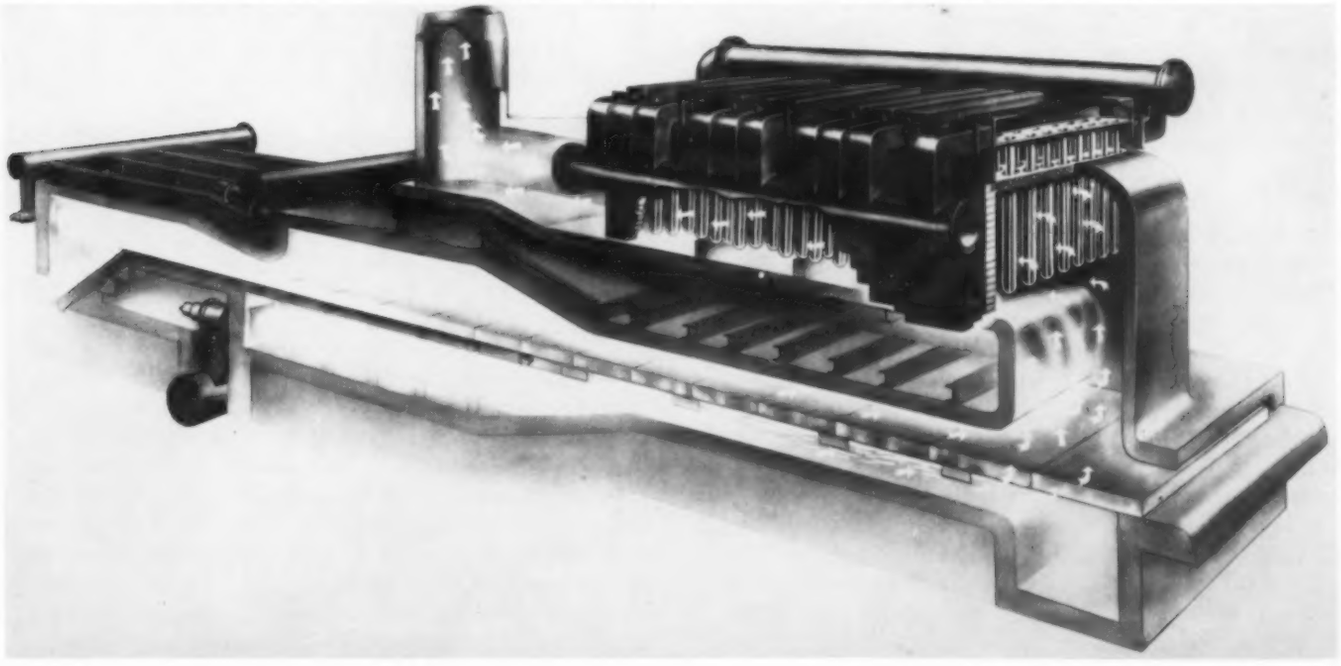


Figure 13 — Recuperator design shown was developed for low overhead clearances.

Figure 14 — In this design, the recuperator is installed above the slab heating furnace.



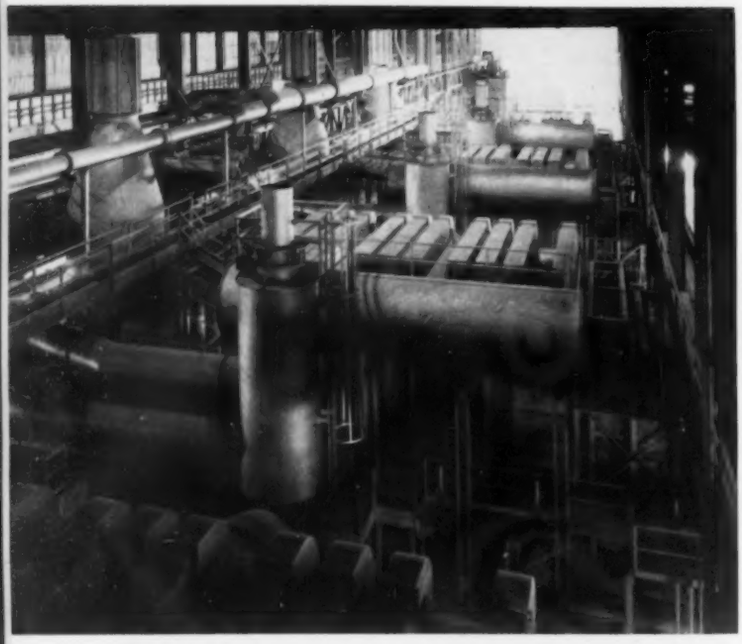


Figure 15 — Emergency air bleeder stacks can be seen adjacent to the furnace and the header boxes can be seen above the several furnaces.

are first taken through a refractory recuperator and then through this metallic recuperator. Relatively high pressure air is preheated in the metallic recuperator and used to aspirate the balance of combustion air through the refractory recuperator. Advantages credited to this arrangement are higher combustion air temperatures than are practical with the refractory recuperator with hot air fan type of installation alone. However, it is believed that the combination refractory-metallic type of recuperator installation will be discontinued in favor of the straight metallic recuperator application as soon as the ability of the latter to provide the desired higher air preheat is proven in this country.

PRESENT STATUS OF METALLIC RECUPERATORS

Today there are only about 125 steel heating furnaces equipped with metallic recuperators in the American steel industry. Although there is still considerable hesitancy with regard to making installations, there is now an active interest in the possibilities.

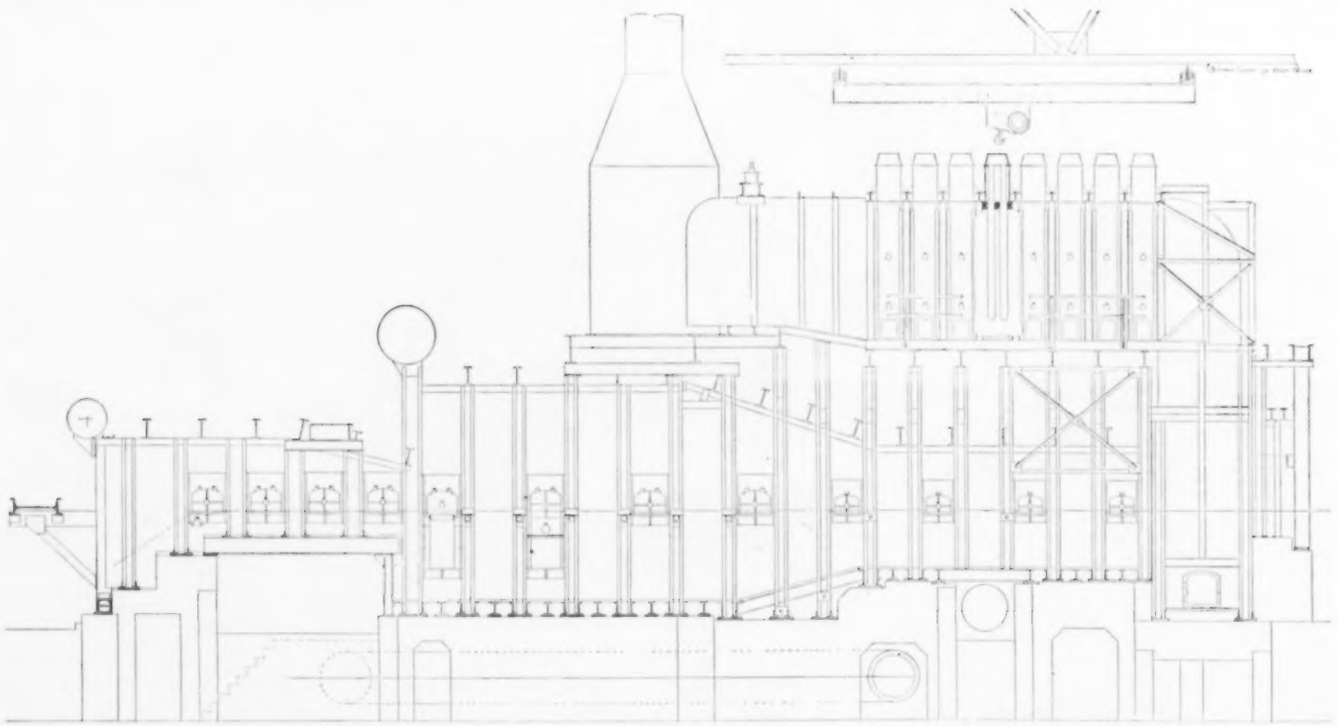
In this respect the picture is reminiscent of the early days of metallic air heaters for boilers, when it was being discovered that the use of preheated air was valuable not only for improving fuel efficiency, but also for increasing the steam generating capacity of the furnace. Once this was established, the air heater was quickly accepted and is now widely used.

It is believed that the hesitancy with respect to metallic recuperators for steel heating operations will likewise rapidly disappear as it becomes apparent that properly applied preheated air is an excellent vehicle for increasing the heating capacity of the furnace and improving the quality of heating, as well as a means for attractive fuel savings.

Air heaters are reportedly credited with raising the effective steam generating capacity of boilers as much as 20 per cent with fuel savings up to 9 per cent. In comparison, recent installations of metallic recuperators have shown effective heating capacity to be increased as much as 20 per cent, with fuel savings up to 30 per cent.

The labor situation in this country has changed materially in the past twenty years and industry generally is being forced by the economic pressure of high wage and material costs to an ever-increasing production efficiency. In this connection, the use of metallic

Figure 16 — Entire recuperator and stack is either supported by separate steel work or by extending the furnace buckstays.



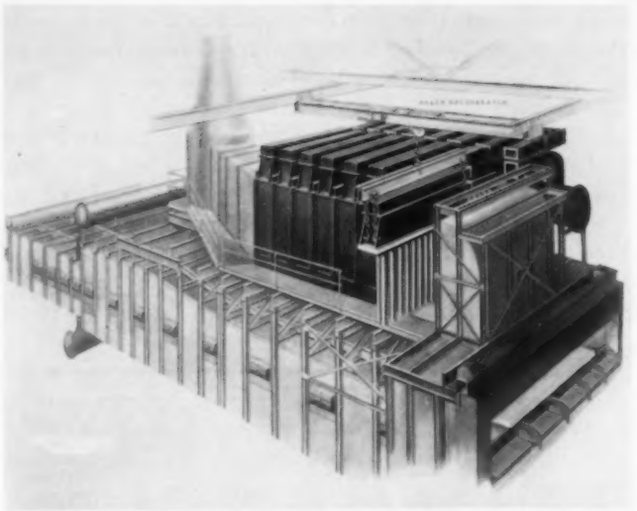


Figure 17 — In this installation, a small crane has been attached to the lower cord of the building trusses to aid in serving the units.

recuperators in heating furnace operations offers an excellent opportunity for the steel industry to make substantial savings in production costs.

DISCUSSION

PRESENTED BY

E. W. FITCH, Chief Combustion Engineer, Republic Steel Corp., Youngstown, Ohio.

G. H. KRAPF, Technical Assistant, Fuel and Power, Steel Operating Div., United States Steel Corp., Pittsburgh, Pa.

H. B. HELM, Fuel Engineer, Youngstown Sheet and Tube Co., East Chicago, Ind.

F. H. BREMMER, Combustion Engineer, Spang-Chalfant Div., The National Supply Co., Ambridge, Pa.

ARNOLD F. ROBBINS, Combustion Engineer, Crucible Steel Co. of America, Midland, Pa.

HAROLD V. FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio.

FELIX KRAUTMACHER, Combustion Engineer, Spang-Chalfant Div., The National Supply Co., Pittsburgh, Pa.

WALTER N. FLANAGAN, Power and Fuel Engineer, United States Steel Corp., Pittsburgh, Pa.

FRANK D. HAZEN, President, Hazen Engineering Co., Pittsburgh, Pa.

E. A. VIEROW, Superintendent, Fuel and Power Dept., Youngstown Sheet and Tube Co., Youngstown, Ohio.

E. W. Fitch: The requirements for good recuperation on continuous buttweld pipe furnaces are very exacting, and the service severe. The refractory tube recuperators, with which our furnaces of this type were originally equipped, left much to be desired. Contamination of the combustion air was a continual problem despite frequent repairs and high maintenance cost. Fuel-air ratio control and measurement was consequently inaccurate and the maximum air temperature attained under the best condition was not over 800 F.

About three years ago, in an attempt to improve these conditions and increase production, the four recuperators on the two hottest zones of one furnace were replaced by two recuperators of the cast metallic tube type.

Each recuperator consists of eight rows of horizontal tubes — twelve tubes wide. The air is introduced from the pressure blower through the top row and three bottom rows — returning through the four middle rows — thus making two passes. The waste gases travel vertically down over the tubes in one pass.

The first five rows of tubes are cast of a chrome-iron alloy, whereas the bottom three rows are of cast iron.

Waste gases leave the furnace at temperatures up to 2800 F and are reduced to 1800 F by a dilution air fan before entering the recuperator. Air temperature is easily maintained at 1000 to 1050 F. There is no waste gas contamination and air flow can be accurately measured, providing improved fuel-air ratio control.

Substantial gains in tons per hour, and fuel economy were obtained from this installation. For the first two and a half years no repairs or maintenance of any kind were required, however, about six months ago we did have failures of four tubes in one recuperator and two in the other. All but one of these were straight cast iron tubes and unfortunately near the bottom where they are not easily replaced.

These tubes have been plugged off, without appreciably affecting furnace operation, until an opportunity arises for a sufficiently long shutdown to replace them.

G. H. Krapf: Our metallic recuperators are of the type designated in Mr. Vierow's paper as the Hazen recuperator.

We operate five continuous slab heaters, which were equipped with metallic recuperators approximately five years ago, at one of our sheet and tin mills. We have for comparison, four continuous slab heaters of approximately the same size and heating capacity equipped with refractory recuperators, operating in another plant.

These two installations are heating practically identical product. There is, however, a difference in average slab weight between the two units which is principally due to heating a greater number of "half length" slabs in the four furnace unit. Since two "half length" slabs are several inches shorter than a full length slab, hearth coverage is not quite so good. Careful consideration of this factor indicates that for the following comparison the effect should not be sufficient to balance out the difference in "net Btu per ton heated."

The statistics for 1952 show these facts.

Fuel rate on the furnaces equipped with metallic recuperators was 1,560,000 Btu per ton. On the furnaces equipped with refractory recuperators it was 1,830,000 Btu per ton. This represents about 17 per cent higher fuel usage for the furnaces equipped with refractory recuperators.

In the same period, production rate was 33.2 tons per thousand square feet of heating area per operating hour on those furnaces equipped with metallic recuperators vs 31.2 on the furnaces equipped with refractory recuperators.

Average slab weight was 13,000 pounds for the first case, and 9000 pounds for the second. This of course could influence the above results, but probably not too much in this case since a change in slab weight has

been made in the second plant, starting in the first months of this year, which has brought the average slab weight up to about 10,500 pounds without materially changing the differences noted in the fuel rate of the two installations.

Our maintenance experience with the metallic recuperator has been satisfactory. They have remained tight and continue to deliver the designed volume of air to the burners, and of course since they operate under pressure, there can be no dilution of combustion air with flue gases.

Early in the operation of these recuperators, difficulty was experienced with salts deposited on the outside of the tubes. This difficulty was eliminated when the source was traced back to the type of fuel oil used. R. R. Shedd reviewed this in his paper, "Metallic Recuperators for Slab Heating Furnaces." See 1951 Proceedings AISE, p 423. No additional difficulty or maintenance problems have come to our attention since.

Of additional interest is the installation of metallic recuperators on three continuous slab heaters feeding one of our plate mills. This service is quite severe since, at times, hot slabs from the slabbing mill are charged into these furnaces. This results in exit gas temperatures of as high as 2000 F and better leaving the furnace. Some difficulty was experienced with blistering of the first row of tubes because of this excessive temperature. The difficulty was alleviated by bleeding a controlled amount of air in the flue system ahead of the recuperator. This was controlled from the air temperature leaving the first box of the recuperator bank. No further difficulty has been experienced.

Of further interest may be the fact that there are installed at Fairless Works, four continuous slab heaters and one continuous billet heater equipped with metallic recuperators.

H. B. Helm: There are several facts mentioned which are of particular interest; first, the cycle through which the method of recuperation has passed from metallic to refractory, and now apparently the trend is toward metallic, or at least more interest is now being shown in metal recuperators than for some time.

Second item of interest is the description of the so-called "packaged unit" of the Thermal Transfer recuperator. This appears to be a clever method of increasing furnace capacity and improving furnace efficiency, particularly on older furnaces where space is at a premium.

Third is the characteristic of the present metallic recuperator which permits the delivery of relatively high pressure air to multiple burner installations.

Our experience with metallic recuperators closely parallels the description just given, however, I must add that our experience is limited.

We have a continuous pipe mill in operation equipped with four Thermal Transfer type recuperators. The furnace is of conventional design, being 160 feet long by 2 ft 9 in. wide, equipped with 364 burners. It is fired with either oil or gas, depending upon the availability of the latter. Skelp heated varies in width from 9 to over 17 in. With waste gases diluted to a temperature of 1775 F, air preheat temperatures are around 900 F.

We also have a billet heating furnace equipped with similar recuperators. This furnace is 54 ft long, 37 ft wide, and heats billets up to 2⅞ in. thick by 12 in. wide. It is fired with either a coke oven gas-blast furnace gas mix, or a combination of fuel oil and blast furnace gas. The furnace is base loaded with a constant amount of blast furnace gas with the automatic temperature control varying the coke gas or fuel oil input to satisfy heat requirements. Monthly average Btu per cu ft of the combined gases is around 250. Preheated air temperature average between 750 and 800 F. No tempering of the waste gases with air has been required. As is the case of the pipe mill furnace, no repairs have been made to the recuperators since their installation over three years ago. Due to the small clearance between the fins or needles on the waste gas side of the recuperator elements, some plugging was expected from scale carried over by the waste gases, however, this has not been the case.

One triple-zone-fired slab heating furnace equipped with metallic recuperators has recently been put into operation. This furnace is 18 feet wide by 80 feet long, and is rated at 70 to 80 tons per hour. It is fired with 100 per cent fuel oil. Slabs vary from 4 to 7 in. in thickness. Due to the necessity of metering combustion air after the recuperators, both air flow meters and fuel flow-air flow controls are temperature compensated.

Based on limited observation, preheated air temperatures will vary between 800 and 1000 F, with waste gas entry temperatures of 1700 F.

Fortunately, the scarcity of fuel is not as great nor the quality as low here in this country as in Europe today. However, the trend is in that direction.

Since the first metallic recuperator was installed in this country 15 years ago, the country as a whole has doubled its consumption of energy, and 95 per cent of this energy has come from underground fuels, more than half being natural gas and petroleum.

With this tremendous rate of consumption of fuels, there is little doubt that their availability for steel mill use will decrease accompanied with increased costs. Obviously this trend will force the use of more and more heat recovery apparatus in an attempt to offset these rising costs.

F. H. Bremmer: Approximately five years ago, our company installed two triple-fired bloom heating furnaces, one having a capacity of 100 tons per hour, the other 60 tons per hour. After careful study and looking over other types of recuperators, we specified the Hazen metallic tube recuperator.

The recuperator for the 100 ton per hour furnace is equipped with 200 heating elements, comprising 200 outer and 200 inner tubes. These outer tubes are made of type 309 stainless steel (25 Cr - 12 Ni) Alloy. The inner tubes on the inlet end of the recuperator, 70 in number, are also made of stainless 309. The balance of the inner tubes (discharge end), 30 in number, are made of mild steel tubing.

The heating elements for the 60-ton furnace are of a proportionately smaller number.

A bleeder valve is installed in a stack connected to the hot air duct between the furnace and the recuperator. This bleeder valve is equipped with an automatic temperature control from the hot air in the duct in order to provide sufficient air through the recuperator at all times, regardless of the quantity of hot air required for the burners. Each recuperator is equipped with this

device. This control arrangement has proved quite satisfactory.

Usually, the flue gas temperature entering the recuperator is 1700 F and the corresponding preheated air temperature is approximately 750 F.

Each furnace heats blooms from 8½ to 15 in. squares and approximately 16 ft in length. These furnaces have been in operation for five years, and during most of this period have been in production 20 turns per week. We have had no maintenance expense whatsoever in connection with these recuperators or the automatic temperature control which operates the bleeder valves. Upon a recent inspection of the heating elements, the tubes appeared to be as good as at the time of installation. We have never carried any spare parts for these two recuperators, and we feel that it will be some years before replacement parts will be required.

Arnold F. Robbins: The first experience the Midland Works of Crucible Steel had with metallic recuperators was in 1947 when two Hazen type recuperators were installed to preheat combustion air to a batch-type heating furnace in the hot strip mill department. At the time of installation extensive data was collected to compare this furnace with similar furnaces not equipped with recuperators. An analysis of the data collected revealed a substantially higher production rate in tons per hour along with a 16 per cent lower fuel rate in Btu per ton on the recuperator equipped furnace. This efficiency was short lived, however, as we encountered what appears to be the one weakness in this tubular-type recuperator, burned out tubes.

In 1952, two blocks of producer gas fired regenerative type soaking pits were to be replaced with more modern installations. After much discussion an all-metallic type recuperative pit was chosen. This type was selected for three reasons:

1. It was more easily adaptable to our confined space.
2. Since most of our heating is done with alloy steels, the higher flame temperatures associated with high preheat air temperature could not be taken advantage of in the initial stages of heating.
3. Fuel savings to be realized from higher preheat air temperatures did not begin to offset the higher installation costs of other type pits.

The needle point type recuperator was chosen, delivering preheated air at 900 F. The metallic parts of the recuperator are protected by tempering the waste gas temperature to 1800 F with the introduction of cold air. These recuperators have been in operation for a year now and, as of this date, we have not encountered any difficulties to warrant opening the recuperators for inspection.

It is not the purpose of these remarks to condemn or praise any one type of metallic recuperators. With proper maintenance and application, either type can be of great benefit to furnace efficiency.

Harold V. Flagg: Our slab furnaces are quite unusual in that they receive hot slabs directly from the slabbing mill with surface temperature around 2000 F, and their sole function is to replace the heat lost on the tables and through the slabbing mill.

These furnaces formerly were operated with waste heat boilers and cold air, and required a very high heat release in restricted furnace space, resulting in extremely high maintenance cost and shortened furnace life.

All four of these furnaces were rebuilt three years ago with improvements in furnace refractories, rearrangement of firing, more comprehensive control, and most important of all, elimination of the waste heat boilers and installation of Hazen recuperators. The performance of the improved furnaces has been quite acceptable since slab heating is improved, fuel consumption has been reduced almost half, and furnace life and availability are greatly improved.

Attention is directed to the fact that the flue gases enter the recuperator at temperatures well above 2000 F and air preheat is maintained at 1000 F without difficulty and without undue recuperator maintenance.

Felix Krautmacher: When in the past, emphasis was laid upon furnace production as justification for the installation of recuperators, so has today, due to steady increase in the cost of fuel, the economical aspect of furnace operation moved to the front.

Increased production and fuel savings which can be directly attributed to recuperation are in many cases so attractive that one really wonders why recuperators are not standard equipment on all furnaces. Mr. Vierow has given the answer to such speculation: faulty design of early recuperators, too much dependency on human element for protection and general lack of attention.

During the 15 years, Spang-Chalfant in Etna has operated metallic recuperators on continuous buttweld furnaces, we have accumulated experience, sometimes painfully, to successfully operate this type of equipment. These can be boiled down into five fundamental requirements:

1. The size of recuperators must be subject to careful study and calculation so that they will not become a bottle-neck for a future demand for higher furnace production.
2. Since a successful recuperator must be tight against air losses or infiltration of waste gases, the erection must be executed with utmost care.
3. They should be free to expand and contract.
4. All instrumentation which safeguard the recuperators against overheating must be in good working condition at all times.
5. Periodic inspection.

It might be said, that these points are rather obvious. Of course they are. But, as Mr. Vierow pointed out, these are almost the very same points, which made the earlier metallic recuperators an acknowledged failure, and it is possible that a disregard of these points can be the start of history repeating itself.

On a recent visit to Germany I had the opportunity to see the manufacturing process and erection of metallic recuperators. It was interesting to observe this highly specialized business developed over 25 years. In several steel mills I visited, I saw this type recuperator on forging furnaces, soaking pits, billet heating, continuous buttweld furnaces and others. It was interesting also to hear that the experience over there with metallic recuperators are fundamentally the same as ours.

Walter Flanagan: I would like to call your attention to two points which I do not believe have been emphasized. One is the question of materials. We have had metallic recuperators with us, from 1909. The earliest ones I know of were plain cast iron tubes with packed joints and low air and gas velocities. These were followed by wrought iron or carbon steel tubes of

similar design. There were failures with these, but instead of analyzing the failures as was done in the power plants, the tubes were discarded and then the industry went into an era of refractory recuperators. Many furnace users, both pro or con on metallic recuperators, have failed to analyze the maintenance of the non-metallic as well as the less desirable performance on the basis of air leakage, and lower air temperature particularly on reheating furnaces. Most non-metallic recuperators require ten to one hundred per cent replacements a year. Now, we are just in a new era of metallic recuperators. There have been some recent failures of metallic recuperator elements. The only complete failure occurred when contaminents in the gases caused failure of rolled stainless sheets welded into tubes. A few others have had a slight amount of splitting at the welds, sometimes due to carelessness and sometimes due to operation in excess of designed temperature.

There is before us not only already developed metals, but also the realm of present and future development of materials on which depends both improved recuperation and the future history of internal combustion turbines and steam plants.

The second item, namely the thermal by-pass, is one that forms the difference between success or failure of high temperature metallic recuperators. It can also improve the performance of many non-metallic units. The by-pass is of two types — one consists of maintaining a constant air flow and therefore velocity through the recuperator by-passing back to the atmosphere any heated air not required by the burners after maximum permissible preheat is attained.

The other method consists of admitting cold air into the waste gas flue ahead of the recuperator. A combination of both methods may be desirable. The second method is not available if flues, stacks or induced draft fans are inadequate.

As early as 1922 a recuperator constructed of ordinary steel pipe operated for three years with 1600 F waste gas and 500 F preheated air temperature while protected with the preheated air by-pass.

Frank D. Hazen: When we discuss the possibility of applying our recuperator to increase the tonnage of furnaces which are, at the time, equipped with refractory recuperators and hot fans, frequently we get a most peculiar reaction from the prospective customer's engineers. One having had no experience with our device and thinking back, wonders just how we can increase the production when the limit has been reached with a hot fan and refractory recuperator. It then becomes necessary for us to instill a new trend of thought and quite often this is not an easy task, for it is a known fact that the longer people have certain ideas in their minds, right or wrong, the more difficult it is to change their thinking.

Immediately, some prospective customers only think of a few hundred degrees of additional preheat to achieve this result. It is true that with higher air temperatures, the flame temperature will be increased, raising the heat head which increases the pounds of material heated per hour over the hearth. This is, of course, an important factor but do not forget there are other contributing factors to this result. They are: 1. elimination of leakage in the recuperator, 2. ability to more successfully operate furnace controls, 3. ability to utilize higher air pressures to the burners.

Elaborating on these points for a moment, here is what happens when an effort is made to increase the tonnage output from a furnace equipped with a refractory recuperator and hot fan. The gases in the flue increase in quantity, the draft is limited by the stack, the velocities of the flue gases are reduced, and the hot air fan keeps on pulling with its maximum suction. Such refractory recuperators cannot be kept tight for any definite period of time. Slight cracks occur early and increase in size with age. Consequently, the flue gases are pulled into the combustion air. The more the furnace is pushed, the more this condition predominates. Although this condition may cause an additional false temperature of the air by possibly 150 degrees, this in no way compensates for the detrimental effect of contaminating the combustion air with the flue gases. Consequently, the elimination of leakage is a most important advantage toward increasing furnace production.

Some years ago, tests were made by Professor Trinks in the laboratory at Carnegie Institute of Technology. At that time he recirculated waste gases and mixed them with the combustion air, which showed that these gases had such a retarding effect on the combustion that when the volume of waste gases equalled the volume of the air, the flame went out. Ignition could not be maintained even when the volume of the air was preheated to 1600 F. In a refractory recuperator, the volume of leakage of course is not so great as in those experiments, but the leakage is still sufficient to depress the flame temperature seriously.

Another disadvantage of the refractory recuperator is the difficulty of controlling the furnace accurately, since the air pressure produced by a hot fan seldom exceeds 6 in. of water column, and when the pressure drop through the ducts and the pressure required for the burner are deducted from this, the pressure available for control purposes is uncomfortably small. Greater air pressure from the cold fan through the recuperator to the burners is available with our metallic recuperator, which is also a contributing factor to more tonnage.

When a designer and vendor of equipment makes certain statements concerning his product, some in the audience always feel that the remarks have a semblance of sales talk. However, "the proof of the pudding is in the eating." We have equipped such furnaces, as mentioned, with no other changes to the furnace whatsoever, except the addition of our recuperator and have increased the tonnage substantially.

E. A. Vierow: The discussions have confirmed the author's findings that the two different recuperators currently being marketed in the United States for use in the steel industry are giving excellent results. Each has particular advantages and disadvantages, depending on application. The few minor troubles reported emphasize the importance of attention to details of engineering application and the necessity for a little preventative maintenance.

The scope of this paper was confined to the American steel industry. I should like to suggest that a future paper covering metallic recuperators used in the European steel industry would prove very interesting to the AISE.

TENSION REGULATOR on Kaiser Temper Mill

. . . . operating results of the tension regulating system described have exceeded expectations . . .

By W. R. HARRIS
Manager

and

L. F. STRINGER
Steel Mill Engineer

Industry Engineering Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.

▲ THE temper rolling of steel strip is an art requiring a good deal of science if material having reasonable flatness, good surface quality, and prescribed hardness is to be produced consistently at high tonnage rates. In this process, hardness is imparted to annealed strip by cold working without the use of lubricants and if the strip is thin, very high roll pressures are required to produce reductions of only a few per cent. If the roll pressure is excessive, the resulting roll flattening may be the limiting factor in the amount of reduction obtained. The effect of forward and back tension in reducing roll pressure is well known and consequently it is advantageous to maintain these as high as possible, consistent with strip strength. If a uniform product is to be obtained, these tensions must be accurately regulated. This paper will discuss the magnetic amplifier tension regulator recently installed on the 44-in., 4000-fpm, two-stand, temper mill at the Fontana Works of the Kaiser Steel Corp. for the achievement of this objective.

Figure 1 — Kaiser two-stand temper mill, a 44-in. unit, can roll at speeds up to 4000 fpm.

A front view of this mill is shown in Figure 1. The strip is unwound from the pay-off reel at the left, passed through the entry tension device and into the first mill stand. This stand is of four-high construction, the work rolls having a nominal diameter of 9 in. and the back-up rolls have a nominal diameter of 44 in. The bottom back-up roll is the driven member. The use of small work rolls minimizes roll pressure and driving the bottom back-up roll removes the possible limitation of torsional stresses in the work roll necks and permits a wider mismatch of roll diameters. Emerging from the first stand, the strip passes directly into the second. This stand is of two-high construction. The work rolls, of which only the bottom is driven, have a nominal diameter of 28 in. Normally very little reduction is taken in this stand, the principal purpose being the control of surface quality. The strip continues through the delivery tension device and is wound on the winding reel at the right. Strip tension is maintained between all elements of the mill, but principal attention will be focused on the control of the tension between the mill stands.

A schematic diagram of the mill drive is shown in Figure 2. The pay-off reel is directly connected to a

200-kw, 225/1000-rpm drag generator. The bottom and top rolls of the entry tension device are connected to 100-kw, 690/1200-rpm and 200-kw, 690/1200-rpm drag generators, respectively, through off-setting gear units. The first stand is directly driven by a 600-hp, 225/350-rpm motor, and the second stand is directly driven by a 600-hp, 400/550-rpm motor. The top and bottom rolls of the delivery tension device are connected to 500-hp, 690/1200-rpm and 250-hp, 690/1200-rpm motors, respectively, through off-setting gear units. The winding reel is directly driven by a double-armature, 300-hp, 225/1000-rpm motor. All drives are connected to a common bus which is supplied with power from two 1000-kw, 600-volt, d-c generators. Booster generators are provided for each of the mill members.

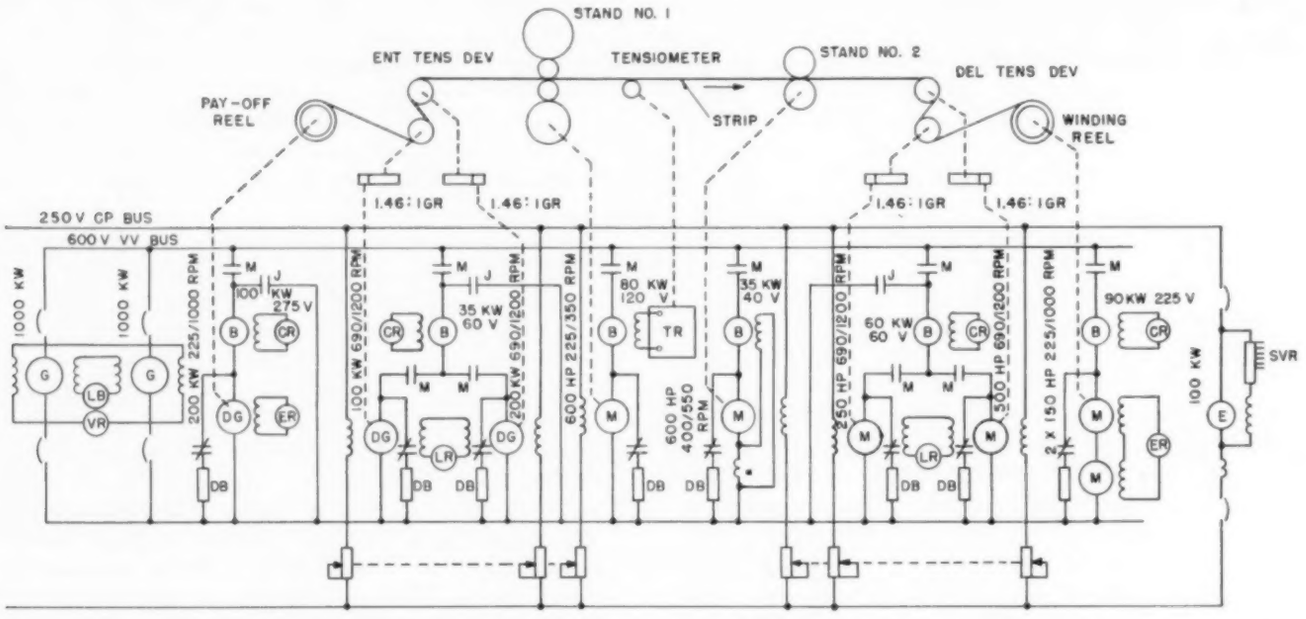


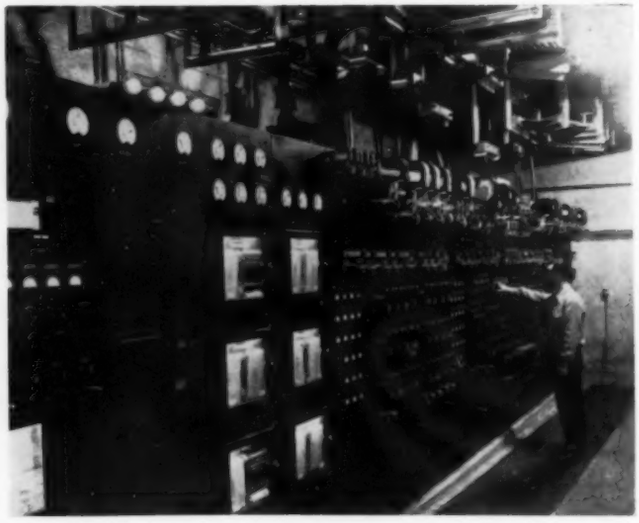
Figure 2 — Schematic diagram of main circuits of the two-stand temper mill drive.

Tension between the pay-off reel and the entry tension device is indirectly controlled by controlling the armature current of the drag generator by means of a rotating regulating exciter acting on the field of the booster generator. The generated voltage of the drag generator is made proportional to the strip speed by means of a second rotating regulator acting on its shunt field so that the strip tension will be made directly proportional to the armature current. This same scheme of tension control is used for controlling strip tension between the delivery tension device and the winding reel. In the case of the tension devices it is not necessary to compensate for continuously changing coil diameters as it is for the pay-off and winding reels, and therefore the second rotating regulator is not needed. Strip tension between these devices and the mill stands is controlled by controlling the total armature current of the top and bottom roll drives by means of a rotating regulator acting on the field of the booster generator. Another rotating regulator acting on auxiliary shunt fields of these drives maintains a preset division of load between the top and bottom rolls.

Strip speed is set by the speed of the second stand. In order to keep it relatively independent of load, the driving motor of this stand is provided with IR drop compensation by means of a booster generator excited from the IR drop of the motor interpoles. Tension between stands is controlled by means of the booster generator in series with the motor driving the first stand. This will be discussed in more detail later. The bus voltage is controlled by a rotating regulator which supplies the field excitation of the 1000-kw generators. A second rotating regulator acting on auxiliary shunt fields maintains the proper load division between the two generators. The mill is accelerated and decelerated by raising and lowering the reference voltage supplied to the voltage rotating regulator. The motors driving the mill stands are individually jogged from the main mill generators. All of the other drives are jogged from the associated booster generators. A front view of the main drive variable voltage panelboard which is located in the mill basement is shown in Figure 3.

In order to control the strip tension between stands some means must be introduced for measuring it in

Figure 3 — Mill drive control panelboard is located in mill basement.



terms of an electrical quantity. This can be done by deflecting the strip with an auxiliary roll as shown in the pass line diagram of Figure 4 and measuring the strip tension indirectly by measuring the force exerted on the roll by the strip. A force diagram, considering the strip to be perfectly flexible and neglecting the small torque required to match the peripheral speed of the roll with the speed of the strip, is shown in Figure 5. For equilibrium, the vertical and horizontal components of strip tension must balance the horizontal and vertical components of the roll reaction force (P). That is:

$P \sin(\gamma) = T \cos(B_2) - T \cos(B_1)$

$P \cos(\gamma) = T \sin(B_2) + T \sin(B_1)$

Solving for the reaction force (P),

$$P = 2T \sin \frac{B_1 + B_2}{2}$$

For our purposes, since the deflection angles are small,

$$\sin \frac{B_1 + B_2}{2} = \frac{2H}{L}$$

so that the reaction force is given by,

$$P = T \frac{4H}{L}$$

This force is directly proportional to the strip tension provided that the height of the roll above the pass line remains constant. The reaction force (P) can be measured by mounting the deflector roll on cantilever springs as shown in Figure 6. The deflector roll is a seamless tube approximately 6 11/16 in. in diameter and 44 in. long. The roll is rigidly mounted on a shaft which is carried in grease lubricated cylindrical roller bearings. The bearings are carried in housings that are assembled in pedestals and these are carried by the cantilever springs as shown. The springs are made from high carbon spring steel and are bolted to the tensiometer frame. Adjustable mechanical stops mounted on the end of the cantilever springs engage pads extending from the frame at extreme limits of deflector roll movement. The position of the frame with respect to the supporting structure can be varied by means of a motor driven mechanism. The supporting structure carries the frame and the height adjusting mechanism and is bolted to the mill housing.

The deflector roll is supported by two springs and the sum of the reaction forces acting on these springs must equal the total reaction force (P). If the strip is centered on the roll and the tension is uniformly distributed over its cross section, the total force will be equally divided between the two springs. On this basis, the variation of spring deflection with strip tension when the top of the roll is 2 3/4 in. above the pass line is shown in Figure 7. Under all conditions the strip tension is proportional to the sum of the deflections of the two springs.

The deflection of the spring is measured by the electro-mechanical device shown in Figure 8. This device consists of a laminated magnetic frame, two series connected excitation coils, a pick-up coil and an

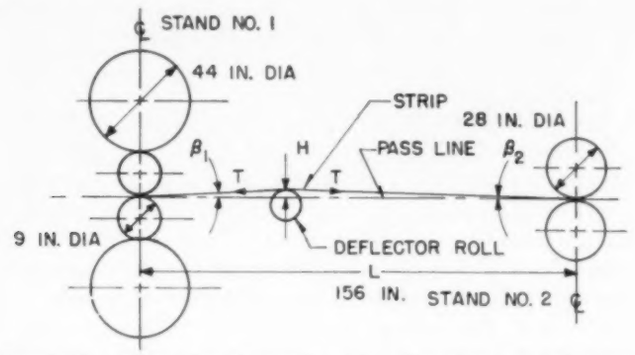


Figure 4 — Pass line diagram shows location of deflector roll.

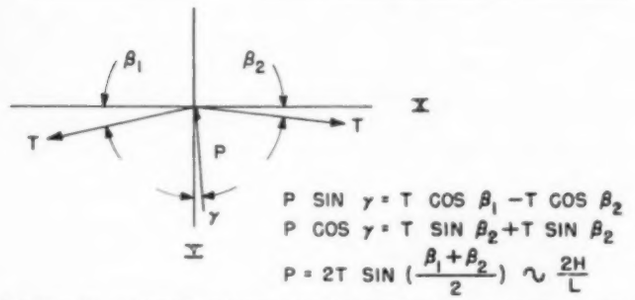


Figure 5 — Sketch shows forces acting on deflector roll.

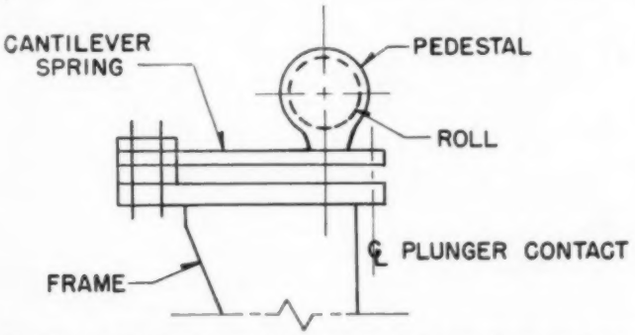


Figure 6 — Deflector roll is mounted on cantilever spring.

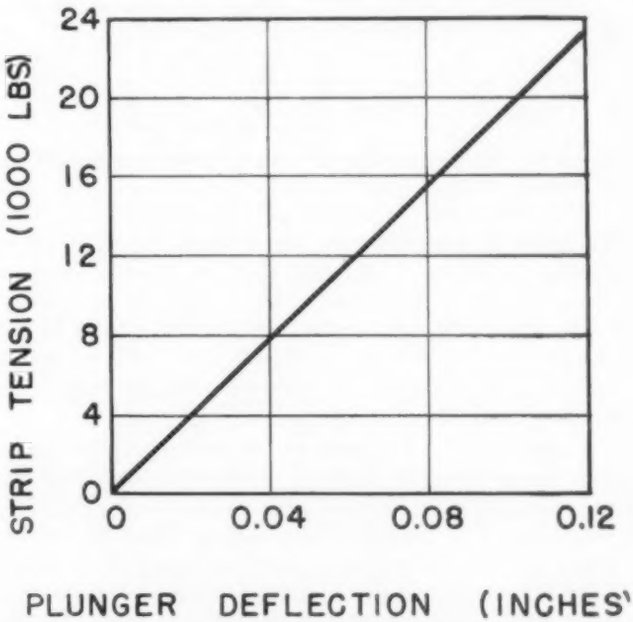


Figure 7 — Spring deflection varies directly with strip tension.

armature whose angular position with respect to the poles can be changed by means of a plunger. This plunger is operated by a contact connected to the end of the spring. The connecting linkages are not shown. When the strip tension is removed, the armature is centered with respect to the poles on which the excitation coils are wound and the reluctances of the magnetic circuits indicated by the dotted paths are equal. The net flux linking the pick-up coil is zero and there is no induced voltage. As the strip tension increases, the resulting deflection of the armature increases the pole embracement in one circuit and reduces it in the other.

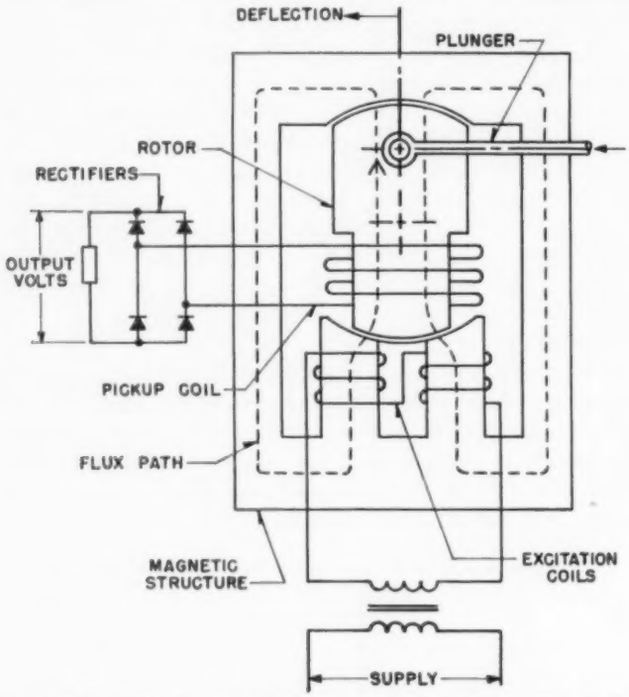


Figure 8 — Schematic diagram shows arrangement of detector unit.

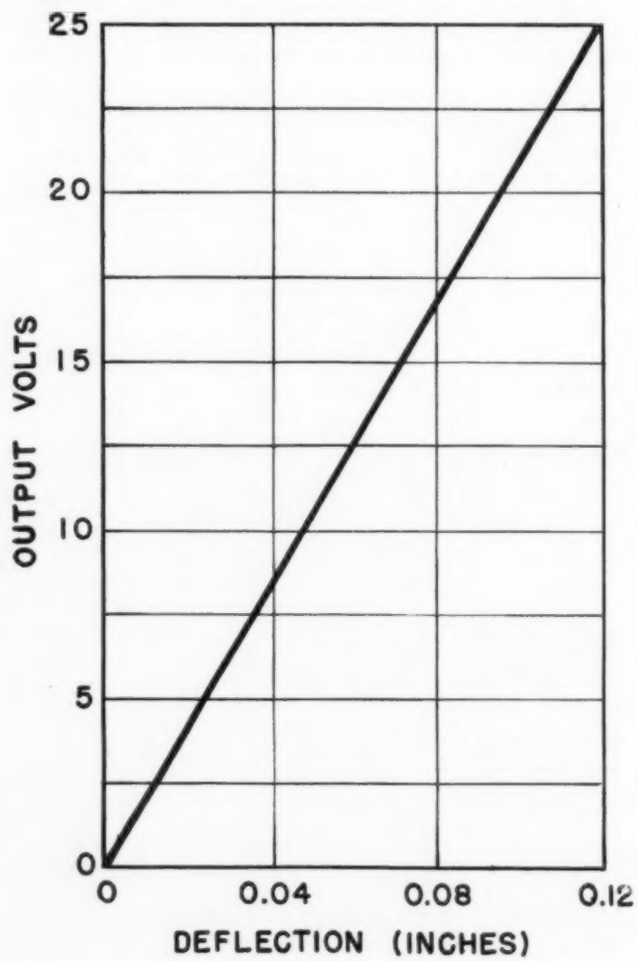
The resulting unbalance in the reluctances of the two circuits establishes a net flux linkage which induces a voltage in the pick-up coil. This voltage is alternating and is converted to a direct voltage by means of the full wave rectifier. The variation of rectifier output voltage with deflection is shown in Figure 9 and the two are seen to be linearly dependent.

The mass of the deflector roll is very small compared to the force required for unit deflection which permits the tensiometer to follow the strip under all operating conditions. The natural frequency of the tensiometer is well above the frequency of any oscillating forces which may be applied to the strip, such as those produced by roll eccentricities. Since the response of the detector unit is within one half of a cycle of the supply frequency, its output will follow the variation of strip tension practically instantaneously. A view of the tensiometer, as installed on the delivery side of Stand No. 1, is shown in Figure 10.

When under tension, the strip applies a torque to the work rolls of each mill stand through the action of the frictional forces existing within the roll bite. The strip pulls forward on the first stand and backwards on the second. If the speed of the first stand is decreased relative to the second by reducing the applied voltage, the strip between stands will be elastically elongated and the tension will be increased proportionally until the reduction in applied voltage is offset by resulting changes in the IR drops in the armature circuits of the two stands. Similarly, if the speed of the first stand is increased relative to the second by increasing the applied voltage, the tension will decrease until the speeds are again balanced by changes in the IR drops. The elongation produced by the applied tension greatly exceeds the change in loop length produced by the corresponding deflection of the tensiometer roll. The effect of the tensiometer roll on strip tension, therefore, can be considered negligible.

The strip tension between stands is controlled in this manner by bucking or boosting the voltage applied to the motor driving the first stand. Depending on friction and rolling loads, this motor may or may not act as a drag generator. Normally the load is very light except during acceleration when almost rated motoring torque is required to produce the speed change alone. A schematic diagram of the tension regulating system is shown in Figure 11. A two-stage magnetic amplifier having forward and reverse channels is supplied with tension control information from the pick-up units previously described, and provides the booster generator with the field excitation required to produce an armature voltage that will buck or boost the bus voltage by the proper amount to maintain a constant strip tension. The details of one of the magnetic amplifier stages is shown in Figure 12. It consists of

Figure 9 — Curves show output characteristics of detector unit.



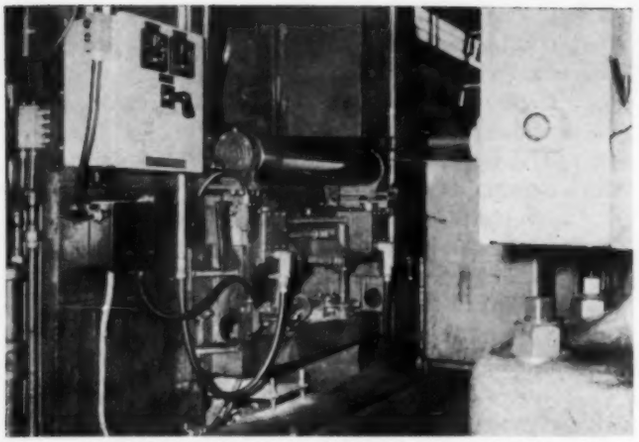
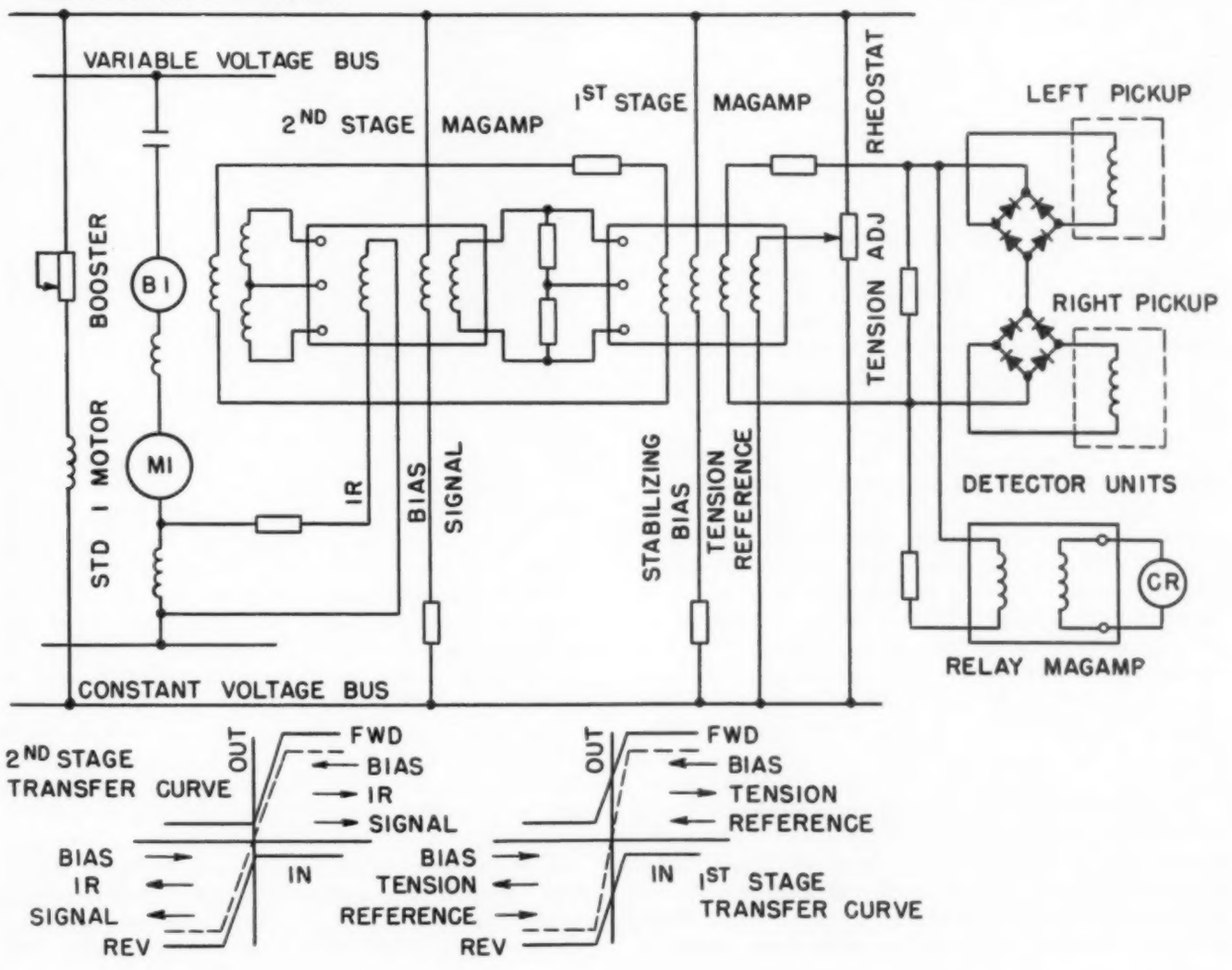


Figure 10 — Short travel regulating tensiometer in operation shows totally enclosed detector units on each side and motor driven jacking mechanism for changing height to accommodate different mill roll diameters.

two standard self-saturating magnetic amplifiers connected back to back to provide forward and reverse operation. Each channel is provided with a transformer to supply 230-volt, 60-cycle excitation, two reactors, each having a ferro-magnetic core on which is wound a load winding and several control windings, self-saturating rectifiers so that the load windings of the two reactors conduct on opposite half-cycles of the alternating supply voltage (while the core of one reactor is driven towards saturation by the voltage applied to its load winding, the core of the second reactor will be reset from saturation by the action of the net excitation supplied to its control windings), and output rectifiers to produce a direct output voltage. The average output voltage is determined by the amount the cores are reset from saturation and this in turn depends on the average net excitation supplied to the control windings. The forward and reverse channels of the first stage are separately biased from the constant voltage excitation bus so that the output from each channel in the absence of other control excitation will be approximately one half of the ceiling value. The input-output or transfer curves of the forward and reverse channels of the first stage magnetic amplifier are shown by the solid lines at the bottom right of Figure 11. The outputs from the two channels are mixed in resistors in order to produce the continuous forward-reverse transfer curve shown by the dotted line. As shown at the bottom left of Figure 11, the forward and reverse channels of the second stage are separately biased almost to cut-off since each channel excites a separate field on the booster generator and it is desirable

Figure 11 — Schematic diagram shows two-stage forward and reverse magnetic amplifier tension regulating system for use with short travel tensiometer.



to minimize field heating. The net field excitation supplied to the booster generator is shown as a function of the net control excitation supplied to the second stage by the dotted curve. Thus continuous forward and reverse operation is obtained, and the booster voltage will either buck or boost the bus voltage depending on the direction and magnitude of the net control excitation. The directions of the control windings are shown on the diagrams presented in Figure 11.

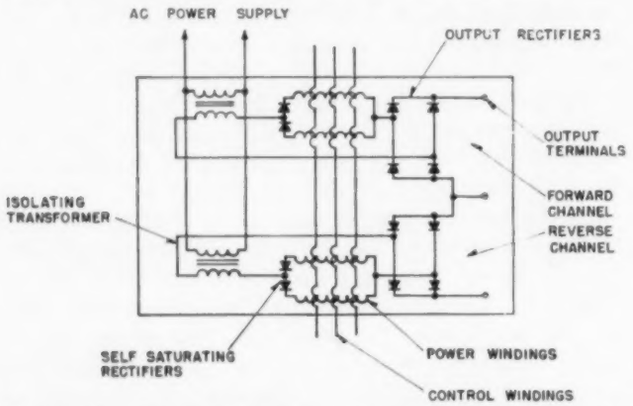


Figure 12 — Schematic arrangement shows double ended magnetic amplifier.

The first stage is provided with three control windings; a stabilizing winding, a reference winding and a tension winding. The tension winding is excited from the sum of the outputs from the two detector units and is proportional to strip tension. The reference excitation is supplied from an adjustable potentiometer connected across the constant voltage excitation bus. The tension winding excitation will increase the output of the booster generator in the direction to reduce strip tension. The control excitation supplied by the reference winding is in the reverse direction. Because of the amplification provided by the magnetic amplifier and the booster generator, only a small change in the net excitation supplied to the control windings of the first stage is needed to produce a large change in the strip tension. Thus if the excitation supplied to the tension feedback winding is much greater or much less than that supplied to the reference winding, the tension will be reduced or increased until this difference is very nearly removed. This results in very accurate regulation of tension between stands. Tension can be easily adjusted by means of a small rheostat located on the operator's control cabinet.

The design of the tension regulating system was aided by a study made on an electronic analog computer. This study indicated that good system stability would be obtained by supplying a separate control winding on the magnetic amplifier of the first stage with a signal proportional to the rate of change of booster voltage. This signal is obtained from an auxiliary field winding on the booster as shown in Figure 11. The agreement between the computer study and actual operating experience is very close as will be shown later.

Since the booster voltage must overcome the total IR drop in the armature circuits of the two stands, the accuracy of the system can be improved by IR compensation. The IR signal for this purpose is supplied to a separate control winding on the second stage magnetic amplifier for the following reasons. When the mill is empty, the tension regulator must be disconnected otherwise it would force the booster voltage to its ceiling value, and greatly reduce or even reverse the motor speed. In order to prevent this, the application of a-c power to the first stage is controlled by a relay energized by a special magnetic amplifier. The output of this amplifier is either very low or very high depending on the presence or absence of a critical signal applied to its control winding. The control winding is excited from the output of the tension detector units. The speed relations of the two stands are set-up so that approximately normal tension is applied when the second stand is threaded. This produces an output from the pick-up units which triggers the relay magnetic amplifier and which by means of relay CR, applies automatic tension control. Therefore, in order to provide IR drop compensation during threading to prevent stalling, it is necessary that it be done through the second stage since the first stage is disconnected. At the same time, the damping action provided by the booster feedback winding is removed and fast response compensation is obtained. The proper threading of a two stand temper mill can contribute much to the tonnage output. This is facilitated by the above control.

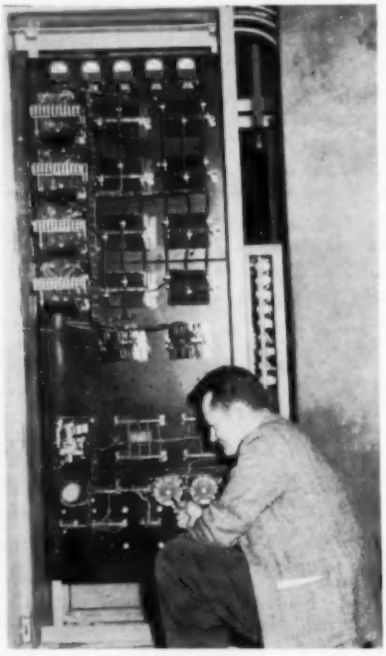


Figure 13 — Magnetic amplifier cabinet shows second stage at top of panel, first stage near the engineer's hand, and automatic tension application relay magnetic amplifier at lower left of panel.

Figure 13 is a view of the magnetic amplifier control panel in use at Kaiser. The upper part of the panel mounts the second-stage magnetic amplifier cores and rectifiers for both forward and reverse channels. The engineer is pointing to the reactors of the first-stage magnetic amplifier. Mounted at the lower left of the panel is the small relay magnetic amplifier used to apply tension when strip is threaded through the mill. The regulating devices are entirely static, panel mounted units. There is nothing which moves or wears out. The long life and low maintenance inherent in such apparatus makes it very attractive to mill operating personnel.

The performance of the tension regulating system under normal operating conditions of acceleration and deceleration is shown in Figure 14. The two top traces show mill speed and mill tension on deceleration from

about 4000 fpm to 480 fpm and acceleration back to 4000 fpm. The next two traces show booster voltage and mill tension during acceleration from 200 to 4000 fpm, and the lower traces show the Stand No. 1 armature current and mill tension on acceleration from 100 to 4000 fpm. Mill tension is maintained within very close limits for the different conditions imposed by the transient operating condition of acceleration and deceleration and the very wide speed range over which the equipment is operated. The large WR^2 of Stand No. 1 compared to the rated horsepower of the driving motor means that the regulating system must provide appreciable forcing to maintain tension. With normal acceleration of 300 fpm per second, nearly rated full-load torque is required for acceleration alone. It takes a very fast and well damped tension regulating system to maintain mill tension so closely under such adverse conditions.

The rapid fluctuations shown on the oscillograms arises from a number of sources. These could be either

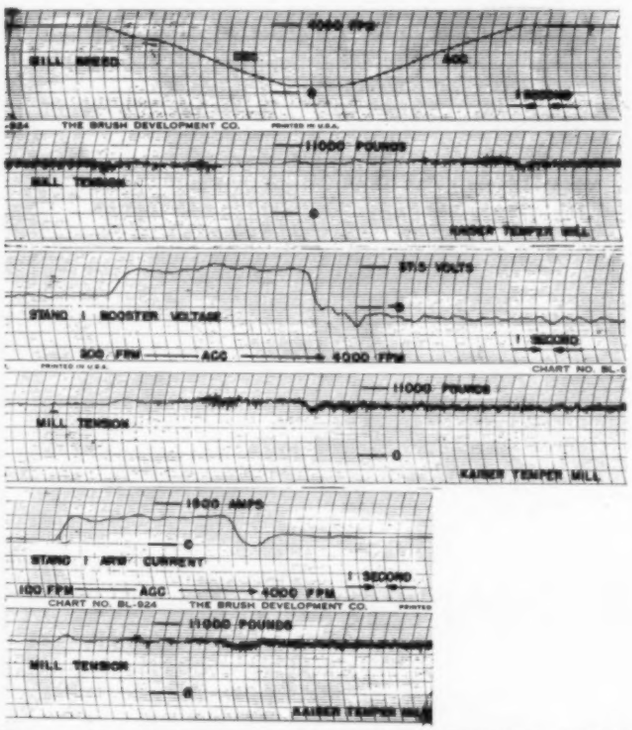
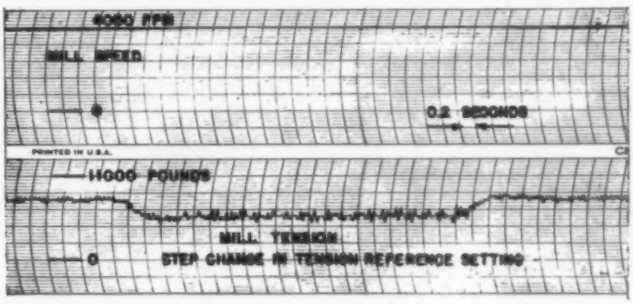


Figure 14 — Performance of tension regulating system during acceleration and deceleration shows that tension is maintained very closely.

eccentricities existing in any of the mill rolls or reel mandrels or the interlayer adhesion in the coil being paid off at the entry end. This latter produces a "pulling and jerking" action which is transmitted to the strip between the mill stands. The frequency of these fluctuations is well below the natural frequency of the tensiometer and the deflector roll tracks the strip closely. The fluctuations occur too rapidly, however, to permit the regulating system to introduce corrective action. This can only be eliminated at the source.

The transient response of the regulating system to a step change in the tension setting is shown in top section of Figure 15. The tension reaches its set value in about 0.4 seconds with very small overshoot. This indicates a very fast and well damped tension regulating system. This response is to be compared with the response of the system as simulated on the analog computer in the design stage on bottom of Figure 15. The correlation is quite good. The analog computer has proven to be a reliable tool of the designer of regulating systems for steel mill drives. Many system adjustments can now be established in the laboratory rather than during installation. This assures that the drive can be placed in



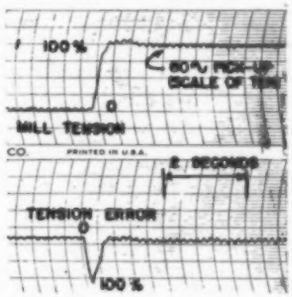


Figure 15 — Transient response of tension regulating system to a step function shows close correspondence between actual operation and analog computer tests. Actual system is shown at top, computed data is on bottom.

operation quickly and smoothly and eliminates lost production which might otherwise occur.

This tension regulating system because of its fast response and good accuracy offers many advantages. The operator has visual indication of tension by means of a meter on the control cabinet and can quickly make changes in strip tension. Results found satisfactory by experience can be consistently duplicated. The ruggedness of magnetic amplifier control systems is well known and maintenance is kept at a minimum. The system described has been in service for over a year and the operating results have exceeded expectations.

DISCUSSION

PRESENTED BY

W. E. MILLER, Manager, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

W. R. HARRIS, Manager, and L. F. STRINGER, Steel Mill Engineer, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

W. E. Miller: The authors have presented a clear and concise explanation of a particular magnetic amplifier application on a temper mill. Other regulating systems on the mill are indicated to be of the rotating regulator type. The paper illustrates the suitability of both types of regulating equipment for particular regulating jobs on cold strip mills.

The magnetic amplifier described regulates tension by voltage control of an 80-kw booster generator. Since booster voltage must reverse, two magnetic amplifiers

are required, each working upon a separate booster field. Herein lies the one major disadvantage of the magnetic amplifier as compared with the rotating amplifier. The magnetic amplifier has the irreversible characteristics of its rectifiers. The rotating amplifier is reversible without complications.

It is not to be inferred that it is difficult to build a reversing magnetic amplifier. It is not. The circuits are well known. The point being made is that it takes more equipment. On small ratings there is no problem. On large ratings, the additional equipment to obtain reversing output may take up considerably more space than that required by a rotating regulator. The benefits to be gained must be considered in making a choice.

The authors have given a picture of a magnetic amplifier with capabilities similar to those of a rotating amplifier. I believe it would be of interest and afford completeness to their paper if the rating of the magnetic amplifier were indicated.

I would like to confirm that experience has been very good with the cantilever spring-supported deflector roll type of tensiometer. We have several hundred such equipments in operation. The small mass and limited deflection (0.1 in.) results in a good pickup device for either a tension indicating instrument or a temper mill tension regulating system.

W. R. Harris and **L. F. Stringer:** As Mr. Miller suggests, and in this there is complete agreement, the various factors affecting the selection of an amplifying device for feedback control systems must be given careful consideration. In some instances, the rotating amplifier will prove to be the proper choice but let us consider the question of reversibility. Certainly more equipment is required to secure reversible operation with magnetic amplifiers than when it is not required. A rotating amplifier is hardly complete without a commutator and it is certainly more complicated when it is included. The additional static elements such as rectifiers and reactors required to provide the magnetic amplifier with reversibility when required are none the less important and must be considered in an analogous manner. But the single, predominant fact remains that the additions are still relatively maintenance free items as compared with the commutator.

In order for the Stand No. 1 booster generator to produce its rated output of 800 amperes at 100 volts, approximately 763 watts of field excitation is required. This power is divided between the two fields, roughly 1.7 per cent being dissipated in the reverse field and 98.3 per cent being dissipated in the forward field. A net field voltage of about 55 volts is required for this purpose. The second stage magnetic amplifier can satisfy these requirements continuously. In addition, this amplifier can increase the net field voltage to 120 volts or 220 per cent for field forcing under transient conditions.

Plan to Attend

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CLEVELAND, OHIO

SEPTEMBER 28, 29, 30, OCTOBER 1

Improved CLEANING Techniques for Open Hearth CHECKERS

By J. J. ENOCHS
Dowell, Inc.
Wilmington, Del.
and
REECE KINCAID
Dowell, Inc.
Chicago Heights, Ill.

. . . . chemical cleaning has been developed into a very effective method for removing solids from checkers . . . .

▲ A newly developed process for chemically cleaning open-hearth checkers, during operation of the furnace, has resulted in improved operating efficiency, reduced fuel and maintenance costs, and increased steel production. A high pressure stream of chemical solvent is jetted against the hot deposits. This tends to cause them to disintegrate, and be removed by the flow of gases passing through the chamber. Nearly a hundred chemical cleaning treatments of this type have been successfully performed on open-hearth checkers in various steel mills throughout the country.

EARLY DEVELOPMENT

The chemical cleaning method was employed initially for removing deposits from blast furnace stove checkers. The excellent results obtained led to speculation regarding whether or not these same techniques could be adapted to open-hearth checkers.

Before the advent of chemical cleaning, open-hearth checkers were cleaned mechanically by poking the accumulated deposits out of the openings with rods. The maintenance program of one eastern mill consisted of blowing out the checker openings with air pressure every twelfth day and mechanically cleaning the checkers three times a year when the furnace was down for a new roof or other repairs.

Mechanical cleaning has a number of disadvantages. Iron oxide deposits are extremely difficult to remove by this method, requiring hundreds of man-hours. Also, this type of cleaning cannot be started until the furnace has been completely shut down and the checker chambers have cooled sufficiently to permit the entry of the maintenance crew. Such cleaning operations frequently have required more downtime than the installation of a new roof.

Figure 1 — First experimental cleaning of checkers gave only partially effective results.

Laboratory experiments first were conducted to determine the practicability of chemically cleaning open-hearth checkers. Samples of checker deposits from several different open-hearth furnaces were subjected to the action of a number of chemical solvents. These laboratory tests, which simulated temperatures and conditions of a checker chamber during operation, indicated that the deposits could be successfully disintegrated by this method.

An experimental cleaning operation was then performed on a small section of a checker chamber, during operation. Following the treatment it was apparent that some cleaning action had resulted, but the brick was still far from clean (Figure 1). From this start, improvements were made in spraying techniques until, after several additional trial treatments, all four chambers of a furnace were cleaned by means of high-

Figure 2 — First checker chamber chemically cleaned successfully is shown here.

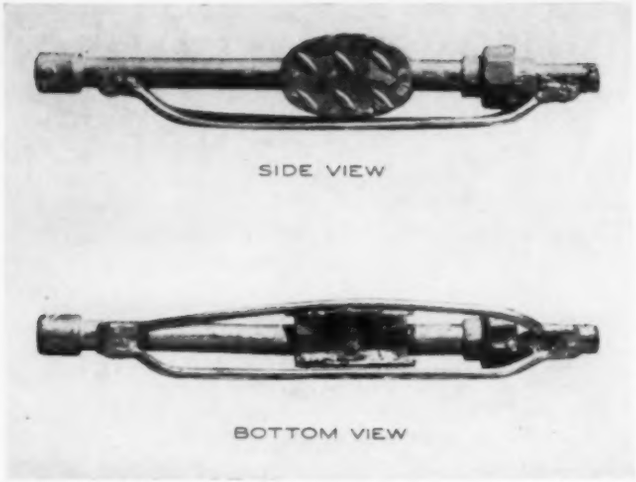


Figure 3 — Jet nozzle for cleaning open-hearth checkers is a special design.

pressure jets in 6½ hours (Figure 2). Man-hours at rebuild time were reduced from over 300 to less than 100. Since that time, continuous improvement has been made, both in equipment and techniques. Additional experience in cleaning all types of checkers is making it possible to improve the process as well as to adapt the general treating techniques to the specific requirements of each individual furnace. On the basis of the results obtained to date, there is every reason to believe that chemical cleaning has provided a practical solution to the problem of maintaining clean open-hearth checkers.

SPECIAL EQUIPMENT

The chemical cleaning technique consists of pumping chemical solvent solutions, at high pressures, through specially designed jet nozzles. These nozzles are inserted in a section of monel barstock, attached to a short length of heavy duty ¾-in. pipe, fitted with a high pressure cap. (Figure 3). A pair of ⅜-in. steel rods act as runners to support the assembly.

This nozzle assembly is fastened to the end of a steel lance, of sufficient length to extend the full width of the checker chamber. Solvent is pumped, by means of a positive displacement triplex reciprocating pump, through a flexible high-pressure hose to the lance, and thus to the jet nozzles.

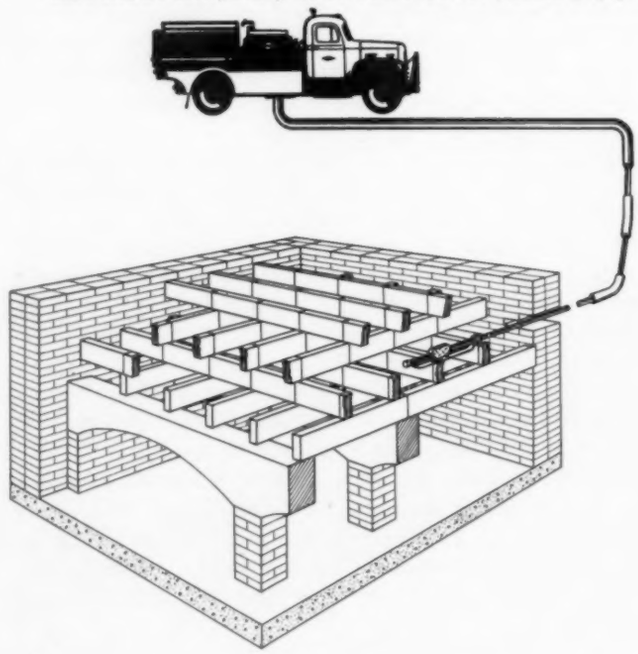
The pump, together with a 1000-gal tank to transport the chemical solvent, is truck mounted so that no permanent installation is required at the plant, and the equipment can be moved from one location to another. Figure 4 shows equipment used in this work.

CLEANING PROCEDURE

Two crews perform the cleaning operation so that two checker chambers may be cleaned simultaneously. Each crew, equipped with a lance and jet nozzle assembly, cleans a chamber. Both lances are operated continuously from the same pump, except during a charge or cast. Each crew begins the treatment by inserting the jet assembly, by means of the lance, into a horizontal checker opening. Temporary openings three to four bricks from the top provide easy entry for the nozzle assembly and guide the nozzles through the

Figure 4 — Mobile pumping units transport solvents to the job.

Figure 5 — Hook-up diagram for cleaning checker chambers shows temporary brick removed for nozzle entry.



horizontal passes (Figure 5). Deposits are usually heaviest in the top four feet of the checkers.

The chemical solvent, at 2500-psi pressure, shoots through the jet openings, both upward and downward, in high velocity streams. When the jets are in line with the first vertical flue, the cool solvent impinges on the hot deposits, transforming them into a fine powder. As the lance is pushed further into the chamber, the jets line up with the second flue and the process is repeated. This is continued until all of the vertical flues connected with that horizontal pass have been cleaned. The jet nozzle assembly is thereafter inserted into successive horizontal passes and the above cleaning procedure repeated until all of the vertical flues have been cleaned.

The special nozzle assembly is then substituted on the lance and the top of the checkers cleaned off. This is accomplished by inserting the lance through openings

Figure 6 — Special design jet for cleaning tops of checkers includes a rake in front of the assembly.

in the bulkhead of the chamber and sweeping across the top of the bricks (Figure 6). The action of the jet streams supplemented by a rake on the front of the assembly, drives the collected material from the top of the checkers into the flues.

This method of chemical cleaning has proved quite successful, even in cases where some of the flue openings were almost entirely blocked (Figure 7). A comparison of the condition of such checkers before and after cleaning may be seen in these photographs (Figure 8).

Cleaning operations are customarily performed during the last heat before the furnace is to come down. If the flue capacity is great enough, the checkers may be cleaned without interrupting a campaign. Otherwise, they must be cleaned just before an outage so that the disintegrated deposits remaining in the tunnels can be removed.

The time required to clean a group of checker chambers depends upon the size of the furnace and the number of heats. In smaller furnaces, cleaning operations can be completed in as little as two and a half hours. Larger furnaces, say of 400-ton capacity, require from eight to eleven hours. In one open-hearth furnace, the total man-hours required for cleaning the checkers was reduced from 685 (mechanical) to 32 (chemical). Chemical cleaning may require no downtime provided the accumulation of deposits in the tunnels is not too great.

Attempts are being made at the present time to utilize a jointed lance, containing flexible metal couplings. If this proves successful, it should be possible to clean checker chambers having as little as 10 to 12 feet clearance on two sides.

About a 400 F drop in checker temperature is usually experienced during chemical cleaning. This will not seriously affect the operation of the furnace. Following the treatment, the checkers return to normal operating temperature.

CASE HISTORIES

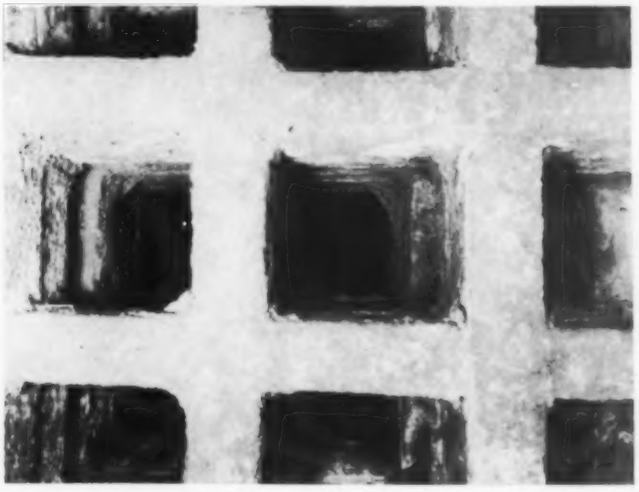
In citing examples of chemical cleaning of open-hearth checker chambers, it is difficult to choose case histories which will be characteristic for all steel plants. Operating conditions, temperature, furnace capacity, charge size, etc., will vary from plant to plant, and "before and after" data for one furnace may be meaningless, in terms of a different installation. In any event, a number of random case histories will be cited to show what chemical cleaning has accomplished *in specific instances.*

In general, the value of the chemical cleaning method may be judged from the increased tonnage obtainable as a result of improved operating efficiency and the reduction of maintenance downtime. In addition, the savings in refractory amount to a considerable sum.

One steel plant reports a savings of 48 hours downtime and $15,000 worth of refractory from a recent chemical cleaning operation. Improved operating efficiency raised the tonnage output from 22 tons per hour to 24 tons per hour.

Figure 7 — Open-hearth checkers, as seen from the top, show heavy deposit.

Figure 8 — Same section of checkers (as Figure 7) after chemical cleaning shows effective removal of solids.



The removal of slag and dust deposits from the surface of checkers greatly increases the rate of heat transfer. The refractory brick take up and yield heat more rapidly, resulting in shorter cycles, reduced stack losses, and lower fuel consumption. A better ratio of Btu to steel tonnage is to be expected following a cleaning operation. Individual shops have analyzed results from this standpoint and report lower Btu per ton, and increased tons per operating hour.

A build-up of deposits in the openings of the checkers will also act as an obstruction to the flow of gases, resulting in a reduction of pressure. Some plants measure the pressure drop from the slag pocket to the main flue, using this figure as an indication of when the furnace needs cleaning. It also will serve as a measure of the efficiency of cleaning operations. Some furnaces are equipped with pressure recorders in the roof of the furnace, recording the pressure in terms of inches of water during the cleaning operation.

Following are listed some of the results that have been obtained in various steel plants as a result of chemically cleaning open-hearth checker chambers:

PLANT A — Open-hearth furnace (350-ton rating)

Before	After
23.4 tons/hour (avg)	24.8 tons/hour (avg)

PLANT B — Open-hearth furnace (400-ton rating)

Before	After
21.5 tons/hour (avg)	24.0 tons/hour (avg)

PLANT C — Open-hearth furnace (400-ton rating)

Before	After
22.0 tons/hour (avg)	24.0 tons/hour (avg)

PLANT D — Open-hearth furnace No. 14 (200 to 225-ton rating) cleaning plus new roof

Before	After
14.5 tons/hour (avg)	15.3 tons/hour

PLANT E — Open-hearth furnace No. 12 (200 to 225 ton rating) cleaning plus new roof

Before	After
15.6 tons/hour (avg)	16.3 tons/hour (avg)

PLANT F — Open-hearth furnace No. 24 (300-ton rating) *no* new roof

Before	After
22.2 tons/hour (avg)	22.6 tons/hour (avg)

Chemical cleaning of checker chambers plus the addition of a new roof accounted for the following results from a steel plant's No. 6 furnace (rated at 205 tons). One additional heat of 219 tons was obtained during a weekly period. The charge-to-tap time was decreased 10 minutes, and the tap-to-tap time was decreased 32 minutes. A decrease of 254,000 Btu per ton of steel was noted. This decrease in fuel consumption amounted to 254,000 Btu × 3259 tons; a saving of approximately 828,000,000 Btu of fuel in one week.

	Before	After
Date	Week of 3-21-53	Week of 4-11-53
Number of heats	15	16
Tons production	3040	3259
Charge-to-tap time	10 hr-10 min	10 hr
Tap-to-tap time	11 hr-24 min	10 hr-52 min
Million Btu per ton	3.779	3.525
Heats on roof	99	20

SUMMARY

It may be seen from the foegoing discussion, that chemical cleaning provides a valuable new maintenance tool to the steel plant operator. It enables him to operate his open-hearth furnaces more efficiently, and allows him to remove blocking deposits from the checker chambers periodically, during operation. Thus it is no longer necessary to operate furnaces with reduced checker efficiency, while waiting for a complete shut down for overhaul.

A great deal of development work has gone into perfecting the techniques for chemically cleaning open-hearth checkers. Improvements are still being made in equipment and solvents. It is felt that, with the continued cooperation and advice of open-hearth supervisory personnel, chemical cleaning will provide even greater benefits to the steel industry.

DISCUSSION

PRESENTED BY

JACK R. LYTHGOE, Production Engineer, Open Hearth Dept., Bethlehem Steel Co., Johnstown, Pa.

J. J. ENOCHS, Dowell, Inc., Wilmington, Del.

W. H. SHURE, Mechanical Engineer, Bethlehem Steel Co., Sparrows Point, Md.

J. A. EKHARDT, Assistant Chief Combustion Engineer, Republic Steel Corp., Youngstown, Ohio.

E. H. CAUGER, Assistant General Manager, Wheeling Steel Corp., Steubenville, Ohio.

GEORGE H. KRAPF, Technical Assistant — Power and Fuel, Steel Operating Div., United States Steel Corp., Pittsburgh, Pa.

Jack R. Lythgoe: The cleaning of open-hearth checkers with a high pressure chemical solvent presents a new approach to the old problem of cleaning checkers.

Although, we at the Johnstown plant of Bethlehem Steel Co. have not tried this method, we are quite familiar with the problems and importance of maintaining a clean checker system for proper regeneration. In our plant, we have tried combinations of steam, water and air with varied degrees of success.

To further clarify the subject, we would like to ask Mr. Enochs and Mr. Kincaid, the following general questions concerning the chemical method:

1. How does the overall cost of chemical cleaning compare with the cost of mechanical cleaning per campaign?

2. Is the equipment portable enough to gain access to the checker chambers as found in the older, more congested shops? We have in mind the pumping distances, maneuverability and availability of the equipment to the working areas.

3. Is the success of the solvent dependent upon the types of fuel that are fired? The iron oxide deposit, which is an indicator of the alkalies present, will vary as much as 20 per cent with different types of fuel. Also, does the solvent further increase checker contamination, with a resultant lower checker brick melting point?

4. Finally, is the work done by your men or are open-hearth personnel trained to handle this equipment efficiently and safely?

In conclusion, we believe that chemical cleaning may have an advantage over mechanical cleaning whenever checker deposits increase the furnace pressure and reduce air preheat in the latter stages of a furnace campaign. Also, the chemical cleaning method should be more efficient than the mechanical method of chipping and bar cleaning during furnace repairs.

J. J. Enochs: In answer to the questions, overall cost of cleaning checkers of any specific furnace per campaign involves a number of factors. In comparing the cost of mechanical cleaning to that of chemical cleaning, the chemical method results in savings in downtime plus increased production from the furnace during the remainder of the campaign as a result of clean checkers.

Although definite cost figures are not available to us, the acceptance of chemical cleaning by major steel companies and the number of furnaces cleaned chemically at regular intervals is an indication that the chemical method is economically acceptable.

The next question was about the equipment; would it reach older type installations where it was too crowded to get the trucks in close to the installation. A pump pressure of 2500 psi is sufficient to assure adequate solvent pressure at the nozzle even though the pump truck may be parked 100 feet or more from the furnace. Even in installations where working space is restricted, if there is sufficient clearance for the lance, chemical cleaning has been successfully performed. As mentioned previously, a jointed lance may adapt chemical cleaning to furnaces previously inaccessible.

Now on the question, does the fuel fired have anything to do with the results. The type of fuel fired definitely affects the deposits, insofar as ease of removal is concerned. While laboratory tests on deposits taken from different installations have not shown the chemical composition to be an appreciable factor, the physical nature of the deposit as laid down (i.e. granular or glazed) plays an important part in determining the difficulty of cleaning.

The nature of this cleaning process is such that no checker contamination is to be expected from the solvents, since the chemicals used are blown out with the disintegrated deposits.

Finally, open-hearth personnel may be trained to handle components of the equipment efficiently and safetly. In all instances, our personnel operate the truck pumps and provide technical supervision during the chemical cleaning operations.

W. H. Shure: This paper gives those of us who have to operate or maintain open hearths something to seriously consider. Every open hearth has its own characteristics. Factors such as the size of the checker chambers, the clearance or head room you have over the checkers, the type of fuel used, and the checker temperatures all influence the effectiveness of this type of cleaning.

There are several questions that I have on chemical cleaning. 1. What are the normal operating temperatures in the checker chambers in which this cleaning is being done? 2. Just what do you mean by mechanical cleaning during the furnace campaigns; or to put this another way, what form of routine maintenance did they have? 3. Just how effective is the solvent you use in your solution?

J. J. Enochs: The normal operating temperatures are from 1800 to 2200 F. To cite routine maintenance procedures is somewhat difficult as I am sure each plant has its own. The maintenance program of the mill referred to in the paper consisted of blowing out the checker openings with air pressure every twelfth day and mechanically cleaning the checkers three times a year when the furnace was down for a new roof or other repairs.

Regarding the effectiveness of the solvent, its purpose is to chemically disintegrate the deposits, allowing the jet streams to sweep them away.

J. A. Ekhardt: I would like to ask what effect does the chemical have on the brick as far as the disintegration of the brick work? Also, have the majority of the plants tried this during operation or during a shutdown?

J. J. Enochs: Laboratory tests have shown that our solvents do not harm the checker bricks. This has been confirmed in our experience during actual cleaning operations. I believe the before and after photographs accompanying this paper show that, although the deposits are disintegrated, the brickwork itself is not adversely affected.

Answering your second question, chemical cleaning is initiated while the furnace is in operation, and the checkers are at normal operating temperatures. The original use for chemical cleaning was to clean the checkers during the last heat so that when the furnace came off for repairs the checkers were clean and would cool rapidly, thus eliminating this maintenance from the furnace re-build, saving downtime.

E. H. Cauger: I would like to know if the dust or the debris that is blown down into the flue is wet when it is blown down, or whether it is light and fluffy so that it can be blown out of the flues?

J. J. Enochs: The jet stream of solvent, after striking the deposit, is broken up into a mist that evaporates rapidly. Disintegrated deposits, in the form of a dry powder, can be carried out the flue in the air stream. Larger chunks of deposit, dislodged from the checkers, drop to the tunnel for removal. In either event, the deposits are dry almost instantly, after being dislodged from the checkers. No moist deposits reach the tunnels.

George H. Krapf: I would like to ask two questions. The statement is made that 1000 psi pressure is used for this work. Was the pressure measured at the lance, or possibly at the nozzle, or was it measured at the pump? Also what is the shape of the liquid stream leaving the nozzle at this pressure? Is it in the form of a spray or of a jet?

J. J. Enochs: We have done considerable experimenting with different nozzles to determine which type would be most effective for this application. We find that our present design has given us the greatest efficiency in cleaning.

Our pressures are measured at the pump. The positive displacement triplex reciprocating pump maintains a pressure of 2500 psi. This produces a pressure in excess of 2000 psi at the nozzle.

The solvent strikes the deposit as a high velocity jet stream.

Import
ORE HANDLING – Machines and Practices

By ERLE M. HAYS, Dravo Corp., Pittsburgh, Pa.

. . . . the use of standard oceangoing cargo boats to haul ore creates problems in the unloading of this material . . . .

▲ AS the American steel industry reaches out across oceans to supplement its reserves of native iron ore, the need for fast and economical methods of transferring this heavy raw material from ships to rail cars, stock pile or barges is readily apparent.

Importation of foreign ores from Liberia, Laborador and South American countries, particularly Venezuela, is expected to increase at a rapid pace. In fact, as much iron ore was imported during the three-year period, 1950 through 1952, as was brought in during the entire preceding ten-year period.

The problems to be considered in unloading and handling imported ore may be classified in three general groups:

1. Types of ships.
2. Types of unloading machines and clean-up equipment for ships' holds.
3. Methods of ore transfer from ships to railroad cars, stock pile or barges.

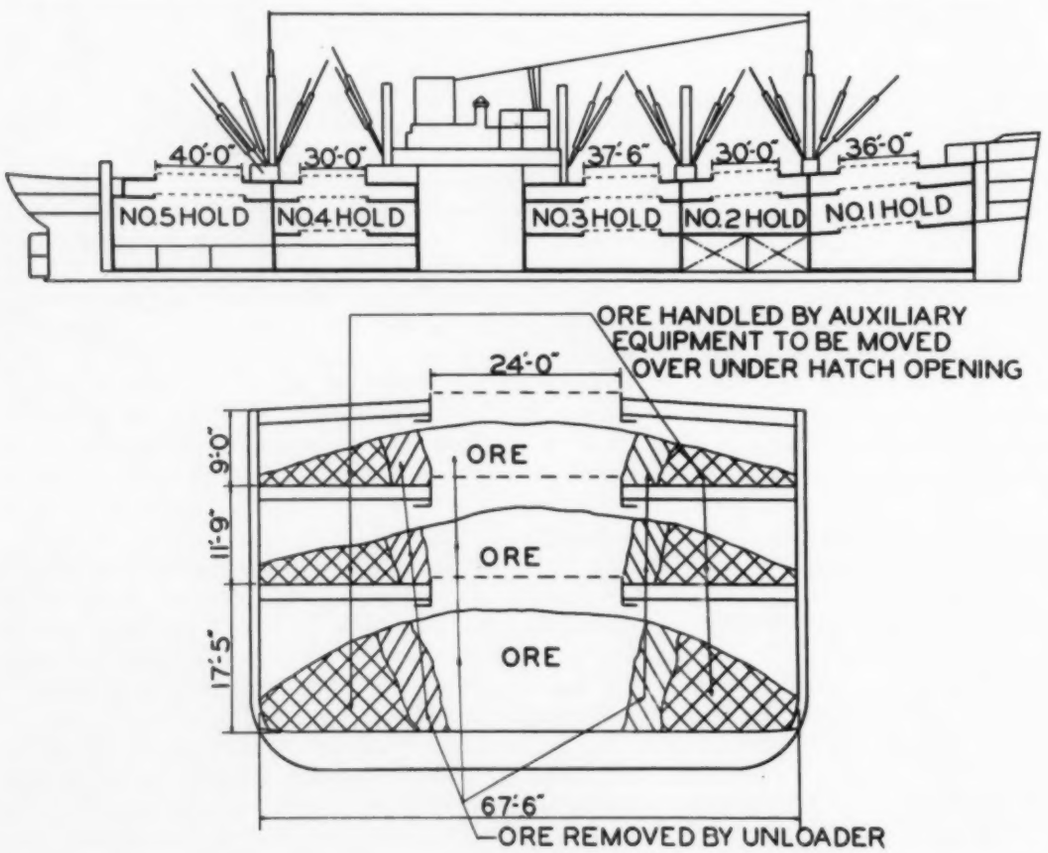


Figure 1 — With the standard type ocean freighter such as the unit shown here, much of the cargo cannot be reached from the hatch opening.

Only a few ocean-going ships specifically designed for transportation of foreign ore are in current use. They are comparable to ore carriers used on the Great Lakes

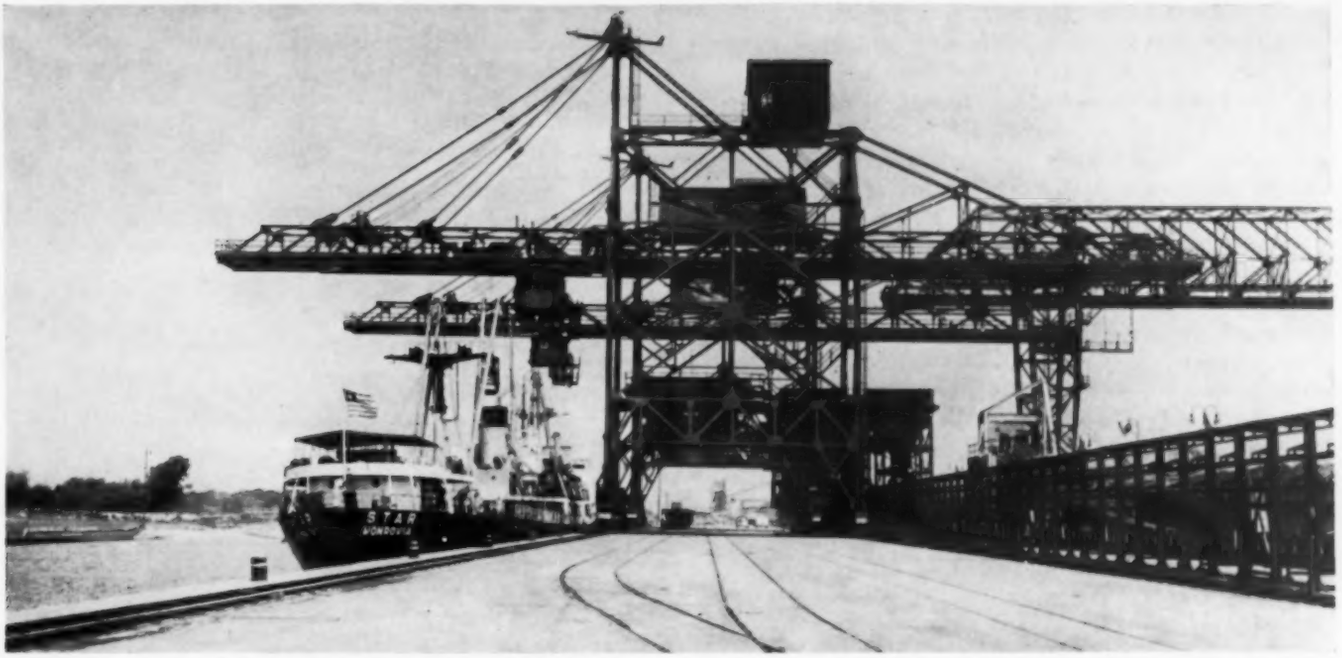


Figure 2 — Ore unloaders shown are the new units in operation at the Fairless Works of the United States Steel Corp.

and usually are of 10,000 to 20,000-ton capacity. The hatch covers over the ore holds can be opened to expose substantially the entire hold area. No ore is stowed under the decks. As ore traffic increases, more of these specially designed ocean ore carriers, some having up to 40,000-ton capacity, will be built.

A large percentage of imported ore is carried today, however, in standard ocean freighters of the American-designed C2, C3, Liberty and Victory types. Figure 1 shows a longitudinal section on the center line and a transverse section through a hold of a C3 freighter. Other freighters are of similar construction. These types of ships, with small hatches and two or three decks, complicate the problem of unloading. It is particularly difficult to unload ore stowed on and under the tween-decks, in the forward holds and in the after holds around the propeller shaft tunnel. The bottom holds in many of these freighters are built with wood flooring, and the sides of the hold are the ship's hull plating with hull ribs protruding. This interferes with the use of automatic mechanical unloading equipment.

For many years in the future, standard ocean freighters will be transporting ore, along with a number of carriers specifically designed for the trade. It therefore is necessary to design modern ore unloaders for handling both types of ships. The man-trolley type unloader is considered to be the most practical and versatile for this service.

Figure 2 is a picture of two new ore unloaders in operation at the Fairless works of United States Steel Corp., on the Delaware River. The front cantilever is a hinged apron which can be raised to clear ship's rigging. When the unloader is idle, waiting for a ship to be docked, the apron is fully raised and a structural steel latch at the top of the tower automatically engages and securely holds it. When unloading a ship, movement of the unloader along the dock is usually made with the apron raised only enough to clear any possible interference. In this case, the apron is held by its lifting ropes. The apron in lowered position is supported by structural eyebar sets and the lifting ropes are allowed to go slack.

Machinery and electrical controls for operating and moving the bucket are installed on a trolley. The operator rides in an enclosed cab located under and built integrally with the trolley. A typical unloader man trolley is shown in Figure 3. The bucket hoist machinery consists of two parallel drums mounted across the trolley frame. One is the bucket closing drum and the other, the bucket holding drum. Each is motor-driven through a gear reduction. An electric shoe brake with each drive stops and holds the drums from rotating. Hoisting or lowering the bucket is accomplished by operating both drives simultaneously. To open or close the bucket, the holding drum is held stationary by its electric brake to keep the bucket from moving up or down. Then the closing drive is operated to pay out cable to open the bucket, or take up cable to close the bucket. The motors used with these drives are identical. For large unloaders, these motors generally are direct-

Figure 3 — Shop view shows typical unloader man trolley.

current AISE frame 618 standardized mill type which provide bucket hoisting speeds ranging from 230 to 300 fpm.

The trolley is spring mounted on four tapered tread, single flanged wheels, accurately machined. Each two-wheel axle is driven by one motor and the two axle drives are operated together. Standardized mill type direct-current motors are used. Motor sizes generally are 612, 614, 616 or 618 frame size and balanced trolley racking speeds are between 900 and 1200 fpm. Each trolley axle drive is equipped with an electric shoe brake. Brakes are applied only under emergency conditions: power failure, limit switch end trolley travel stop, or operator-controlled emergency stop. For normal operation, trolley travel is decelerated and stopped by controlled two-or-three-step plugging of the motors. On these trolleys, which travel at high speed, a speed governor is furnished with the drive. The governor is connected to limit switches that are tripped when the trolley approaches the end limit of travel on the unloader structure. Thus, if the trolley is traveling at an excessive speed, slow-down motor control is automatically established to decelerate and stop the trolley safely.

In Figure 4, the ore bucket is shown being hoisted by the unloader trolley and moved in from a ship's hold toward the receiving hopper built into the tower structure. The cubic capacity of the bucket is selected so several different kinds of ore, having various weights per cubic foot, can be handled without overloading the bucket hoisting motors. Imported ores vary in weight per cubic foot from 115 pounds for certain Venezuelan ores to more than 200 pounds for some Swedish ores. The bucket shown in Figure 4 has a capacity of 200 cubic feet and is used for unloading ores weighing from 150 to 200 pounds per cubic foot. The resulting rated ore bucket load is 15 net tons for 150-lb ore and 20 net tons for 200-lb ore. This bucket is 6 ft-6 in. wide and its length closed is 13 ft-6 in. For digging operation the bucket opens to 18 ft-0 in.

For unloading both ore carriers and freighters, the bucket is reeved to the trolley drums in such a way that the bucket opens perpendicular to the direction of the trolley travel. When the trolley travels on the unloader runway, and starts or stops, the bucket will have some swing. However, being reeved so that its narrow width is parallel with trolley travel, the swinging bucket has greater clearance from the hatch coaming than if it were turned with its long open length parallel with the trolley travel.

From Figure 4, taken during the unloading of an ore carrier, it can be observed that the operator can travel the trolley, lower and hoist the bucket into and out of this ore carrier hold at full speed without hitting the ship's hatch coaming. For cream digging of ore from this hold, the unloader structure remains stationary the greatest percentage of operating time. During clean-up of the hold, the structure is moved as necessary so the bucket can scrape clean all of the ore from the entire bottom of the hold. This figure also shows how the hatch covers on ocean ore carriers can open to expose the entire hold. No ore is stowed back under the deck where it cannot be reached with the bucket.

With this type of man-trolley unloader, these ocean carriers can be unloaded quickly and economically.

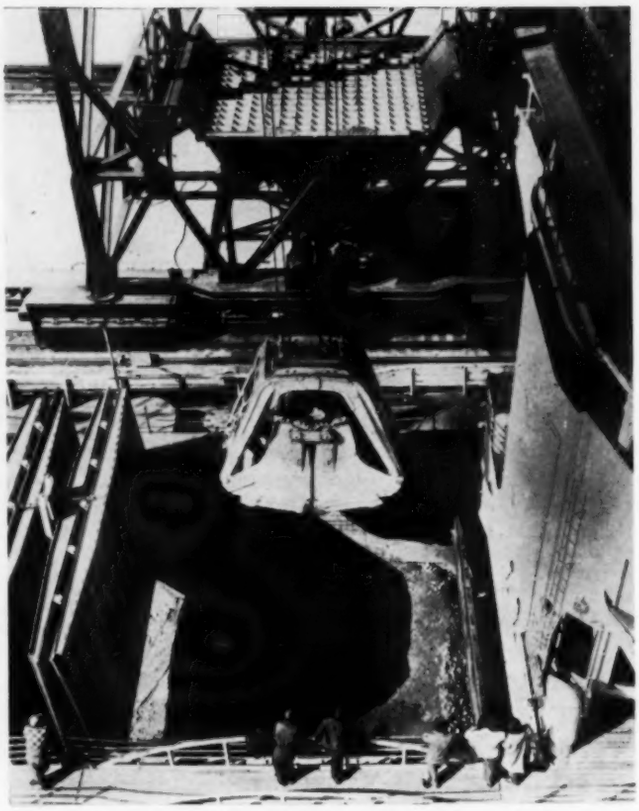


Figure 4 — Ore bucket moves material from hold to receiving hopper built into the tower structure.

With freighter type ships, only the ore located directly under the hatch opening can be unloaded quickly and economically. The ore stowed back under the decks takes much longer to unload. The unloader can be operated to permit the ore bucket lips to reach under the decks a short distance to dig out some ore.

In Figure 1, the drawing of the transverse section through the hold of a C3 type freighter indicates by the crosshatched sections, ore that may remain in the hold after the unloader has removed ore directly under the hatch opening. To take out the larger portion of this remaining ore with the unloader, two operating problems have to be considered. One, rotation of the bucket to a position where its opening length is parallel with the trolley runway to permit maximum reach of the bucket lips under the deck. Two, limiting bucket height so it can work between the decks.

Two man-trolley designs have been developed for bucket rotation. One design accomplishes bucket turning by mounting the hoisting closing and holding drum drives on a turntable that rotates on the trolley. This type of installation uses a parallel "direct-reeved" arrangement of bucket in which two cables from each drum are reeved to the bucket. Usually there are two separate holding cables dead-ended on bucket and drum, and one closing cable with both ends anchored on the closing drum and passing around sheaves in the bucket.

The second design uses a "bight of line" arrangement of the bucket in which two cables, one from each drum, are returned to dead-end connections at the trolley after reeving from hoisting drums through the bucket. These dead-end connections at the trolley are made to a turntable ring which can be rotated to turn the bucket. With this type of design, the bucket rope speed is two times the bucket hoist speed and the ropes travel

through the bucket continuously when it is hoisted or lowered. With the first design, the bucket rope speed is the same as the hoisting speed and the ropes do not travel through the bucket when hoisting or lowering. Theoretically, rope life should be longer using this latter design.

Because smaller buckets are required to reach under the decks on C3 and similar type freighters, some companies decided that unloaders be designed to operate with either of two buckets. The one, a "direct-reeved" large bucket, would dig ore in ship's holds under the hatch openings. The other, a smaller bucket with "bight of line" arrangement reeved to a ring turntable, would clean out ore under the decks. With a turntable arrangement, unloader buckets can be turned in holds to take out ore located approximately five to six feet back under the decks all around the hatch opening.

Even with a turntable rotation arrangement of the bucket, all of the ore under the decks on freighters cannot be removed. Auxiliary equipment must be used to bring out the majority of the remaining ore to the hold hatch opening where the unloader bucket can reach it. In Figure 1, ore that has to be moved by the auxiliary equipment is shown by blocked crosssection lines.

Several types of equipment are now used to recover this remaining ore. Small caterpillar or rubber-tire

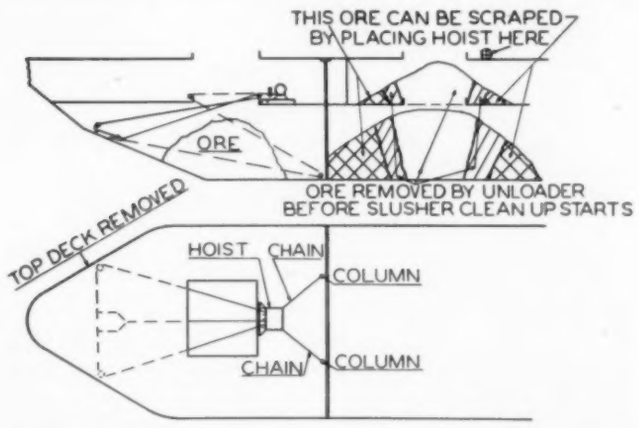


Figure 5 — Slushers are often used to move the ore over to the hatch openings.

bulldozers or loaders have been utilized to move the ore over under the hatch openings. Limited use of this type of equipment for clean-up operations in some freighters has been experienced due to:

1. Space limitation for swinging and backing up in the holds, particularly around the propeller shaft tunnel.
2. Difficulty in obtaining sufficient traction to push or dig into the heavy ore.

Some docks use slushers to scrape ore in these holds over to the hatch openings. Figure 5 diagrams a typical slushing operation. On most freighters there are supporting columns between decks and two chains, one on each corner of the slushing hoist, extend back and tie into these columns. In some cases additional chains are necessary to prevent lateral movement of the hoist unit. (This hoist consists of three drums on a common shaft with clutches for each drum to engage the drum to the drives.)

After the hoist is anchored, the ropes coming off of the bottom side of the two outside drums are reeved around two sheaves, one in each corner of the hold, and connected to the top back side of the scoop. These ropes are called tail ropes and the outside drums of the hoist are the tail line drums. The center drum is the haul drum and the rope from it is attached to the front of the scoop. The haul rope is reeved around a sheave on top of the hatch opposite to the hoist, and then down into the hold through another sheave near the bottom of the hold under the hoist unit. This arrangement prevents an upwards pull when operating the scoop.

Figure 6 shows a slusher hoist in use. The operator of this hoist unit can position the scoop across the hold by controlling take-up and payout of tail ropes individually. He scoops ore moving it to the center of the hatch opening, by taking in the haul rope and simultaneously controlling pay-out of the tail ropes.

Once the hoist is anchored between the decks, ore in that particular hold of the ship can be scooped without removing the hoist unit. Each time the hoist has scraped as much ore as it can pile under the hatch opening, the ropes are laid aside and the unloader is moved in to dig out the ore. Scraping operations proceed again after the unloader bucket completes its job.

In September 1953, a special caterpillar tread mounted machine was delivered to the dock at Fairless works. This machine is about 8 ft wide, 9½ ft high, and 22½ ft long and to its telescoping boom a ½-yd bucket or a scraping blade will be attached. By means of power hydraulics, the bucket or blade on this boom can be extended and retracted, lowered and raised, tilted each way from horizontal and rotated on a horizontal plane. It is expected that promising results will be obtained in clean up of the after holds of freighters with this equipment.

Figure 6 — Slusher is controlled by manipulation of take-up and pay-out tail ropes.

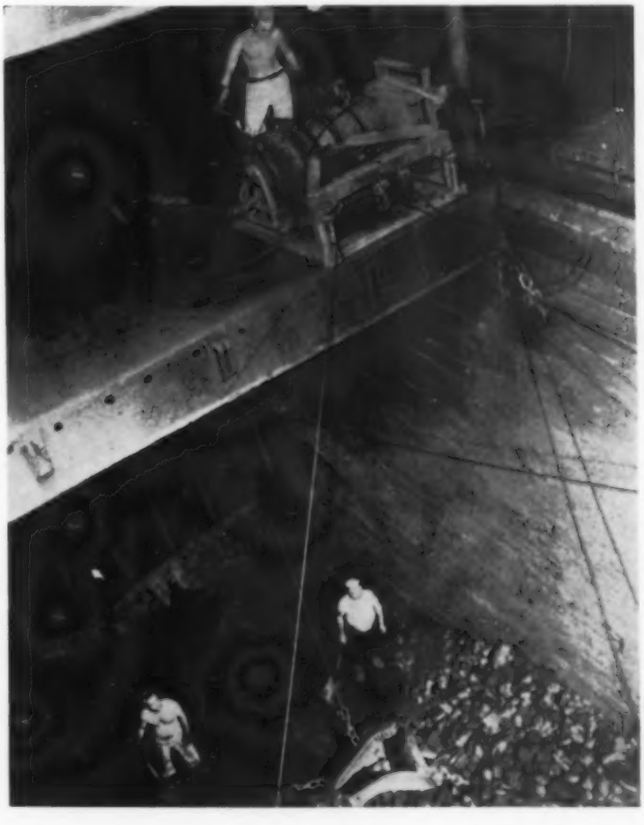


Figure 7 — The ship's propeller shaft gives trouble in efficient removal of the ore from the afterhold.

Lowering and lifting slusher hoists, as well as bulldozers, and loaders, into and out of freighter holds is accomplished by suspending these units with chain slings from lugs on the unloader bucket.

Unloading procedure on most docks is to unload one hold as completely as possible, then lower the auxiliary clean-up equipment. While the clean-up operation of this hold is progressing, the big unloader moves over to another hold where cream digging is possible. When sufficient ore has been moved to the hatch opening by auxiliary equipment the unloader returns and removes it. The unloader often makes several trips back to each hold to take out residual ore moved by the auxiliary equipment.

Even the auxiliary equipment sometimes cannot remove all the ore in a hold, especially ore lodged against the ship's hull sides between the ribs. Figure 7 shows this remaining ore in the afterhold. Manual labor is used to shovel out this ore. Frequently, it is shovelled into small containers and raised by the ship's hoisting rigging shown in Figure 1. This ore also may be shovelled to a location accessible for moving mechanically to the hatch opening.

At one dock there is a traveling hopper to receive ore unloaded by the ship's cargo winches. Figure 8 shows this installation. A belt conveyor at the bottom of this hopper moves ore to an open pile on the dock. After the hold is completely cleaned, the unloader removes this ore.

At steel mills adjacent to docks for unloading ocean carriers and freighters, ore is transferred from the ships' holds by the unloader directly into storage pits under the unloader's landward cantilever. From these storage pits, ore is stocked into the pile by ore bridges. Figure 9 shows the unloading dock, unloaders, storage pit, and ore storage yard at an eastern steel mill.

A large percentage of imported ore is moved from unloading docks to inland steel mills. The basic problems in pier handling and transfer operations from imported ore consigned to inland destinations consist of loading railroad cars or barges to maximum capacity in minimum time without delaying the ship and without

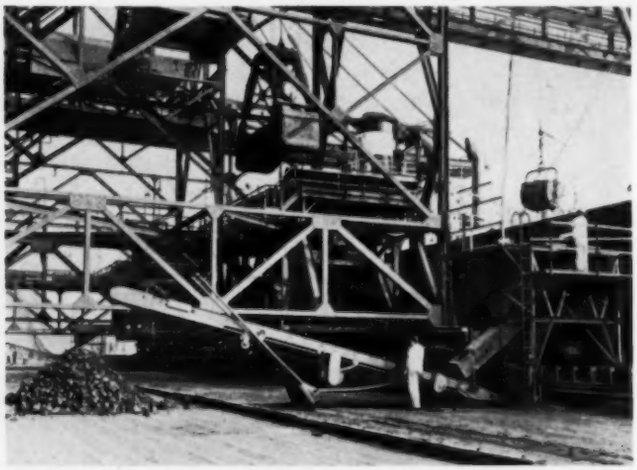
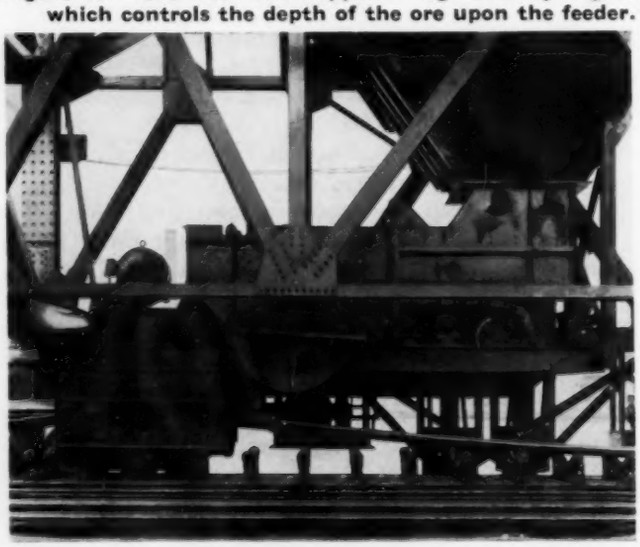


Figure 8 — Traveling hoppers may be used when ore is removed by the ship's own equipment.

Figure 9 — When steel mills are located adjacent to the docks, ore may be stocked into the pile with the steel plant's ore bridges.

Figure 10 — Ore from the hopper is regulated by a gate which controls the depth of the ore upon the feeder.



excessive rehandling. Use of conveyor systems and automatic weighing and loading equipment has done much to overcome these problems.

Early in 1951, the Baltimore and Ohio Railroad Co. put into service a new import ore pier at Curtis Bay in the Port of Baltimore. This modern ore handling and transfer operation provides rapid, continuous and economical handling of ore from ships into railroad cars.

Two unloaders were built for this ore pier. Figure 4 shows the 200-cu ft bucket on one unloader lifting ore from the hold of an ore carrier to discharge it into a 160-ton surge hopper within the unloader tower structure. A heavy bar screen with 15-in. square openings on top of the surge hopper screens out large lumps. Beneath the surge hopper is a heavy duty manganese steel feeder, shown in Figure 10. Ore flow from the hopper is regulated by a ratchet-operated gate which, when set, controls depth of ore on the feeder. This feeder, driven by a variable speed motor, can vary ore feed from 665 to 1330 tons per hour when handling 150-lb ore. A system of rubber impact idlers, mounted on the feeder, supports the main conveyor belt during loading at any point along the ore pier. An arrangement of fingers and chutes at the discharge end of the feeder permits finer ore to fall on the belt in advance of larger lumps. This is to make sure the larger lumps are distributed on a moving bed of finer ore material.

The main conveyor belt, shown in Figure 11 is 48 in. wide, travels 400 fpm and can handle 2000 tons of ore per hour. Ore from this belt is discharged into a 500-ton steel bin, pictured in Figure 12. Located beneath the bin are four manganese steel apron feeders. Each feeder transfers ore from the bin into a spring-mounted scale hopper having a maximum capacity of 40 tons of 150-lb ore. Each hopper is equipped with a motor-operated gate. Figure 13 is a close-up view of the lower part of this bin structure. Two loading tracks and one pusher track pass beneath the discharge bin structure. The 40-ton scale hoppers are arranged in pairs over each loading track.

The car loading operation is semi-automatic. Figure 14 shows the scale dials and controls in the operator's cab. There are two operators in this cab, one to control loading over each rail track. A string of cars is assembled on each track and a card for each car, showing the car number and the maximum pounds of load it can carry, is given to the operator. As a car is moved under the structure to be loaded, the operator sets the scale dial

Figure 11 — It is essential that the ore be taken away from the unloading site asexpeditiously as possible.

Figure 12 — At this pier, ore is taken from conveyor belt into a 500-ton steel bin.

Figure 13 — Ore is fed from the bin into spring mounted scale hoppers below the bin.

Figure 14 — Car loading operation is semi-automatic. View shows scale dials and controls which are located in the operator's cabin.

for each scale hopper to one-half the maximum load of that car. A push button starts the loading cycle by closing the scale hopper gates. Then the apron feeders automatically start delivering ore to the scale hoppers. The scale dial has a flag on the pointer which interrupts an electric eye circuit to stop the feeder when the weight load setting is reached. The operator punches the card for the car on a printer to record the gross weight of the scale hopper. When the track man signals that the car is in position under the hoppers, the operator uses a push button to open the hopper gates, discharging ore into the car. The operator again punches the card to show the tare weight of the scale hoppers, thus recording the net quantity of ore delivered into the car.

The complete installation described is a modern high speed, efficient ship-unloading and car-loading system. Similar installations have been built or are currently built by others.

The Canton Railway Co. in Baltimore has increased the unloading capacity of its dock by installing a third unloader and adding a conveyor belt to transfer ore from unloaders to a new car-loading bin similar in design to the system described above. Before installation of this conveyor and car-loading bin, ore was unloaded from ships into a weigh hopper on the unloader structure and discharged directly into railroad cars. Addition of the conveyor and bin, eliminates the car loading delays experienced because of insufficient tail track on the dock for ore trains.

The Western Maryland Railroad in Baltimore also is adding a new unloader on its pier at Port Covington, and the Pennsylvania Railroad currently is building a new import ore pier in Philadelphia.

In Mobile, Ala., the Tennessee Coal & Iron division of United States Steel Corp. is completing the construction of its new ore dock. In addition to facilities for loading out railroad cars, there also will be equipment for loading ore into river barges. Ore will be carried by conveyor belt to the barge loader. Movement of barges under the loader will be accomplished by a rope-operated barge shifter.

Improvement of machinery and equipment to handle bulk raw materials has kept pace over the years with the many technological improvements made throughout the iron and steel industry.

Operating economy and speed are the primary design considerations engineers strive to incorporate in bulk materials handling equipment. Delays in moving raw materials from their source to processing plants are costly. So it is essential that unloading and loading be completed in the shortest time possible.

Perhaps new special clean-up machines can be developed to speed up the ore clean-up operations in the holds of ocean freighters.

Until additional ships especially designed for ocean transportation of ore are placed in service, the problem of cleaning out holds of standard freighters will continue to cause delays.

DISCUSSION

PRESENTED BY

EDWARD H. D. GIBBS, Contracting Engineer, Heyl and Patterson, Inc., Pittsburgh, Pa.

E. W. COONEY, Sales Engineer, Joy Manufacturing Co., Claremont, N. H.

P. L. TIETJEN, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

ERLE M. HAYS, Dravo Corp., Pittsburgh, Pa.

Edward H. D. Gibbs: Mr. Hays has described many of the problems involved in getting ore out of ocean vessels, together with the technique and equipment used. These are problems which are of intense interest to the users and builders of ship unloading equipment, as well as to the steel industry and to ship operators.

I will attempt to enlarge on a few aspects of these problems. Where large tonnages are to be handled as in these ore importing operations, the major consideration is speed of unloading. This results in quick vessel turn-around and in reduction in the per-ton cost of unloading. Much consideration has been given to the best method of removing, not only that portion of the cargo which can be dug in full bucket loads at the

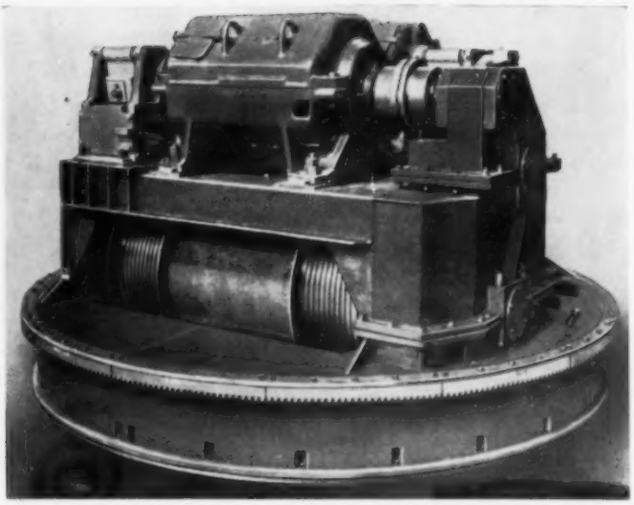


Figure 15 — Turntable type of trolley can be used on both ocean and lake vessels.

fastest bucket duty cycle rate, but also to the problem of unloading that part of the cargo which remains after this "free digging" portion has been removed. This clean-up material amounting to from 20 to 70 per cent of the cargo, depending on the type of vessel and type of ore, is removed at such a slow rate that it brings the overall average for the whole ship down to about 50 to 60 per cent of the maximum of free-digging rate of the unloader. In order to improve this clean-up rate, it is important to be able to turn the bucket in the hold of the vessel, and also to handle the bucket as rapidly as possible in view of the fact that it does not generally have a full load.

Figure 16 — Ore unloading pier shown is so set up that material can be discharged directly from bucket through hoppers into cars or loaded onto a belt conveyor.

In the turntable type of trolley (Figure 15) the hold and close engines, which are the bucket hoisting engines, are mounted on a turntable capable of being rotated about 230 degrees. With this method, the same bucket is used without sacrificing hoisting and lowering speed and without the delay required to change buckets. Based on experience gained through 30 years of operation with a turntable unit on the Canton Co. Pier in Baltimore, we have advocated this type of man trolley for unloading not only ocean vessels, but also lake vessels. Seven of this type have been put into operation in the past three years and four more are being built. Figure 15 is a photograph of a turntable type trolley on one of two 12-ton ship unloading bridges at Dominion Foundries and Steel, Ltd. at Hamilton, Ontario.

The ore pier of the Canton Co. of Baltimore (Figure 16) is an outstanding installation because it has maximum flexibility in the type of cargoes which can be handled. Ore can be discharged either directly from the bucket, or through hoppers into cars on one of four tracks on the pier or be loaded onto a belt conveyor which will carry it to a central weighing and car loading station. This pier receives many split cargoes where this flexibility permits unloading of different ores simultaneously. Recently a ship was received which had 12 consignments, all of which had to be kept separate.

It does not seem likely with the various grades of chrome, manganese, iron and other ores coming from the four corners of the earth, that this practice of small shipments and mixed consignments will appreciably change. It is expected, however, as Mr. Hays pointed out, that there will be a marked increase of large consignments of ore in suitably built ore carriers. This is where the high capacity unloaders feeding onto conveyor belts to remote car loading stations will pay off.

Figure 17 is a construction view of the third unloader

Figure 17 — Unloader shown was designed to handle 20-ton bucket load on a 38-second cycle.

Figure 18 — View shows 1200-ton capacity bin which will be a part of the new Pennsylvania Railroad installation at Philadelphia.

Figure 19 — With the rope trolley type of unloader, the operator is located on the tower structure.

being built on this pier. It should have been in operation in October 1953 and is designed to handle a 20-ton bucket load on about a 38-sec cycle. It is equipped with a turntable trolley and is operated by adjustable voltage electrical control.

Figure 18 shows a high capacity import ore pier now under construction for the Pennsylvania Railroad at Philadelphia. Unit will have two-man trolley, adjustable voltage, turntable type unloaders, both of which can feed onto either of two 54-in. wide steel cord conveyor belts, which will carry the ore into the top of a partitioned 1200-ton capacity elevated bin.

Either or both belts will be able to discharge ore into either bin and thus load onto either of two railroad tracks.

We have spoken so far only of the man-trolley type of unloaders, which are the largest capacity units. However, there are several definite advantages in favor of the rope trolley type of unloader similar to the unit recently completed at Alabama State Docks and Terminals in Mobile and which unloads ferrous ores and bauxite. See Figure 19.

The primary difference between this unit and the man-trolley type is that here the man is located on the tower structure, instead of traveling on the trolley with the bucket. One disadvantage of this location has been that the operator was not able to obtain as good a view of the bucket working in the hold, as is possible when he is located on the trolley. This can largely be overcome by mounting the cab on an extensible boom as shown. In this case, it is possible for the operator to move his cab out over the vessel a distance of 25 feet, and thus obtain a much better view into the hold of the vessel. This type of unloader has the advantage of lower cost because the structure does not have to carry the heavy man-trolley. It requires less expensive runways because of the lower wheel loads for the total structure, and it is possible to operate on a faster cycle because the operator does not have to ride with the trolley, and trolley acceleration is therefore not critical as long as the bucket can be properly controlled. There are at present rope trolley unloaders operating on 22 to 30-sec cycles with buckets up to 7-ton capacity, and similar units are now being built using 12-ton buckets to unload coal from barges.

There has been a very distinct evolution in the design of bucket handling equipment. Duplicate drives for holding and closing drums have, to a large extent, replaced the single motor and clutch assemblies formerly used and which were a constant source of maintenance. Improved electrical equipment in the form of low inertia mill motors and adjustable voltage control has permitted faster operation, the use of larger buckets, better control of the bucket, reduction in operator fatigue, and less chance of damage to ships or equipment, all with a much lower power consumption than was possible with constant potential d-c power. Operators have an inherent fear of moving large bucket loads of material weighing as much as 40 tons total at any appreciable speed unless they have confidence in the control which they can exercise over its motion. Adjustable voltage control has greatly increased this confidence.

In looking to the future, it seems very probable that the greatest factor contributing to increased speed in unloading ocean vessels will be improvement in the design of these vessels, which will permit larger buckets to operate on faster cycles free from obstructions so that a greater portion of the ore can be removed at the free-digging or maximum rate.

Member: Both Mr. Hays and Mr. Gibbs made it quite evident that the real value of the unloading machines which they discussed was the great rate in which they can remove the material from the hold of these vessels and deposit it ashore. It is very plain, of course, that the mechanism or the device or conveyor which is used to take away the deposited material must be equally efficient and have equal peak capacities to the unloading machines, or we are simply going to get ore deposited on the dock.

Unless the ore is deposited directly into the ore cars or barges or storage piles, the conveying system must be considered as an integral part of the complete system, and the same care and thought must be devoted to the design as is devoted to the design of the unloading facilities.

I would like to point out that some of the important design considerations which must be taken under careful consideration are these: Some provision must be provided for the capacity between the discharge of the bucket and the conveyor. Thought must be given to the possibility of sticking of the wet or hard to handle ores in these bins which are normally used as a means directly ahead of the feeder to the conveyor.

The next consideration is that of the controlled rate of feed to the conveyor. This is generally accomplished by control of the depth on the feeder as well as the speed of the feeder. As a rule, these feeders are of variable capacity, are of the apron type, and are of substantial design and construction.

The next important consideration is that of the mode of depositing the ore upon the main belt conveyor itself. Adequate concern must be taken of the factors of impact on the belt, which in turn is a function of drop capacity lump sizes.

Concern must be felt over the weight of the material and the spill also must be given some concern.

You have the proper loading of the belt which is essential, not only to limiting spill, which if not done brings on subsequently a costly clean-up operation. The belt must be loaded properly so that there is no interference to the proper running of the belt.

In many cases, the design of this type of equipment and the arrangement and construction and functioning of the load on the belt has not been given adequate consideration.

Then, above all, we must bear in mind that whatever the conveying means, which takes the ore away from the unloader, the peak capacity of that medium must at least match the peak capacity under free digging conditions of the unloader itself.

In other words, the unloader cannot be designed for the average rate of handling, but the size of belt, speed, belt rate of feed and so on must be proportioned to the maximum peak rate of the unloader.

Then, of course, consideration must be given to the proper innerlock of the unloader and the conveyors.

The cleaning of the belt is of importance whenever ore is being handled. Many ores are sticky and tend to build up on the belt pulleys and may cause considerable embarrassment to the operating peak.

E. W. Cooney: I have only a few minor points to add to Mr. Hays's very excellent presentation.

One is that the slushers which Mr. Hays referred to may be more familiarly known to you as scraper hoists, as generally used in underground metal mining. These machines have three drums and the motor in line, weigh approximately 3600 lb, and are about 80 in. long.

The purpose of the slusher hoists is to scrape the ore into the open space under the hatch, at which point it can be picked up by the unloading clamshell. This work was formerly done by men with wheelbarrows or small hand trucks, and it required as many as 50 men in each hatch, of which there are four or five to each ship, and the operation consumed much time, four or five days. The slushing operation requires very few men, and is much faster than hand labor. It is common practice now at Mobile to completely unload a 10,000-ton ore cargo ship in twenty three to twenty-four hours.

There are now approximately 60 of our three-drum slushers operating in this service: in Mobile for scraping bauxite and iron ore, in Baton Rouge, Corpus Christi, and Trinidad for scraping bauxite, and in Baltimore, Philadelphia, and Norfolk for scraping iron ore. In most cases the slusher hoists are owned and operated by stevedoring companies.

The slushers in Mobile in bauxite are driven by 25-hp, 30-hp, or 40-hp continuous, general purpose, a-c motors, 270 per cent pull out torque, and are totally enclosed, fan cooled, on account of the bauxite dust. The slushers in iron ore are all driven by 30-hp, high slip, high torque, 500 per cent pull out torque, splash proof, a-c motors.

The Mobile operators removed the standard weight type automatic brakes. So many setups and so much rerigging and unwinding of ropes from drums is concerned that they prefer a free rolling drum.

The hauling distance is very short, and a slow rope speed, 200 fpm, drum half full, is preferred. In timing one machine at Mobile with a hauling distance of only 10 ft, and scraper hauling about one ton, the round trip time was less than six seconds.

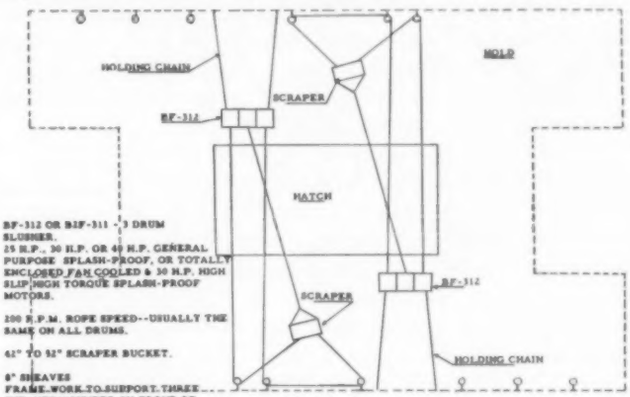

HOLDING CHAIN
SCRAPER
BF-312
MOLD
HATCH
BF-312 OR BIF-311 - 3 DRUM SLUSHER.
25 H.P., 30 H.P. OR 40 H.P. GENERAL PURPOSE SPLASH-PROOF, OR TOTALLY ENCLOSED FAN COOLED & 30 H.P. HIGH SLIP, HIGH TORQUE SPLASH-PROOF MOTORS.
200 R.P.M. ROPE SPEED--USUALLY THE SAME ON ALL DRUMS.
42" TO 52" SCRAPER BUCKET.
6" SHEAVES
FRAME-WORK TO SUPPORT THREE SHEAVES MOUNTED ON FRONT OF SLUSHER
SCRAPER
BF-312
HOLDING CHAIN

Figure 20 — Sketch shows rigging details for slusher operation.

When operating, the slusher hoists are held by chains with a ratchet lever takeup to tighten each chain. These chains are sometimes anchored to the vertical steel columns between the decks. Sometimes there is nothing to hook the anchor chains onto, and this caused trouble at first, as ship captains were reluctant to permit alteration or addition to the ship's structure. Once the captains understood that cooperation on their part would mean the difference between one day and several days in port for unloading, their objections were dropped. The stevedoring companies weld to the deck a number of small steel plates with holes therein to hook a chain onto. These serve as anchors for the slusher hoists, and the job of welding in these steel plates for the whole ship is done in an hour or so.

A final point is that it is common now, at least in Mobile, to use two slusher hoists in a hold instead of one. Figure 20 shows such an arrangement.

P. L. Tietjen: The following are a few observations that I have made over a period of time in handling iron ore on the lakes and having something to do with the ship operation.

The thing I would like to bring out is in the handling of the many types of iron ores and probably you all know of the sticky types and the lump types and the importance of the bucket. Of course, on the lakes we

use the Hulett with a telescopic type tray bucket, and this bucket can, of course, rotate and clean up much better than the type of bucket that is used along the coast. It telescopes to a distance of 4 to 6 feet, and then it retracts and closes so it gives you a scraping or a clawing effect which aids the clean-up.

Now, along those lines, a straight side or an angular type bucket is much better than a clam or arc radius type. When the bucket closes up, it tends to shove the ore out, rather than get a full bucket, and of course, the speed of the unloading is probably one of the most important parts of the operation.

One of the things that I have noticed is the capacities of the various ore bridges and conveying equipment.

We all say tons per hour. Actually, that rate usually pertains to ideal conditions, so when you take the tonnage and attempt to say that a ship is going to be unloaded in so many hours, you are off, because the questionable part of the whole operation is the clean-up when you are not utilizing the rated capacity equipment to the utmost.

I understand that the Hulett type unloader has not been considered on the coast due to the tides and depth of the vessels, but, I would like to ask if it is not something that should be given serious consideration because of the great efficiency of this type unloader.

On the lakes, of course, we are unloading vessels — 12 to 20,000-ton vessels in four to six hours, and that would be way out of range on the coast.

Another observation I have made is that the majority of retractable bridge type cabs has the operator's cab too far above the vessel. One of the comments made was that if the cab or the operating platform could be very close to the deck of the vessel it is operating over, it will be very much better.

Anything that will make the operator nearer to the vessel deck will add to the speed of the unloading.

This heavy type of machinery is very expensive, and much more could be done if the docks could be utilized 100 per cent of the time. Unfortunately most of the ore docks have a ship today and nothing tomorrow. You might say that 50 per cent of the time, at least, is waiting time.

I was very interested in the conveyor belt that was shown in Baltimore. That certainly solves a problem when you come to a narrow pier or a place where you are limited for car storage, because the majority of the lake docks have four or five tracks of which loading cars are consuming considerable space. Of course, when you are on a pier next to the water, you usually have some space limitations.

I would like to ask the author what is the average interval of time for the trip of the bucket into the hold of the vessel and out onto the discharging hopper?

It is very apparent at the present time that the ore carrier for the importation of ore will be built to suit the trade very quickly. We should refrain from using or even stop using the types of vessels where they have between deck storage. I believe that the coast and the ocean operators can learn a lot from the handling of ore in the Great Lakes which is probably the most efficient handling of bulk material in the whole world.

The other day in Ashtabula they handled 100,000 tons of ore on six vessels in a daylight period of about six hours at the three ore unloading docks.

Erle M. Hays: Mr. Tietjen commented upon the excellent performance of Hulett machines in the unloading of boats on the Great Lakes, and has asked the question if serious consideration should not be given to some adaptation of this machine for unloading ocean ships.

One advantage claimed for the Hulett is the precision control of the bucket resulting from the fact that it is carried on a rigid member and has no tendency to turn when passing through small width hatches. This advantage is claimed to offset the higher speeds of the bucket type man-trolley unloader. There is some merit to this claim when unloading small lake boats having hatches with widths of only seven to eight feet. Ocean ships have hatches with widths of twenty feet or larger. Today the modern lake ore boats are built with hatches of nine to twelve feet in width and also a large percentage of the older lake boats are being converted to provide wide hatches. New man-trolley unloaders with buckets from ten to seventeen tons capacity are being used at lake ports and are unloading boats with hatches of nine to twelve feet at equal or better rates than Huletts.

The Hulett as a general rule requires more pier width than the bucket type unloader due primarily to the large moving mass of the trolley. The first cost of a bucket type man-trolley unloader and the dock is considerably less than the first cost of a Hulett and the dock.

Consideration of these factors plus the tide conditions on the coast which Mr. Tietjen mentioned, I believe led to the conclusion to use unloaders instead of an adaptation of the Hulett design for ocean port installations.

To answer Mr. Tietjen's question as to the trip cycle type for the bucket to dig, transport ore to hopper in the unloader, dump and return the bucket into the hold of the ship, the unloaders at Baltimore operate on a 45-sec free digging cycle. As pointed out by Mr. Tietjen the free digging cycle is what the machine can do, but lost time due to clean up, etc, results in an average rate of unloading substantially less than the free digging rate. Mr. Gibbs in his remarks commented that the overall average generally may be down to about 50 to 60 per cent of the machine's maximum free digging capacity. I have observed that in unloading some old tramp ocean ships the average rate sometimes drops to as low as 25 to 30 per cent of the machine's free digging rate.

In designing an unloader it is desirable to keep the operator's cab as close as possible to the top of the ship's main deck, as Mr. Tietjen has pointed out. In Figure 12 the closeness of the cab to the ship's main deck should be noted.

In closing I would again like to mention the problem encountered in tramp steamers to clean out the ore packed between the ribs of the ship next to its hull plating. One dock is now experimenting with a special grade-all machine using a small blade on the telescoping boom. This blade can be rotated to fit between the ship's hull ribs and moved up or down to pull out the packed ore. Whether this method will speed up clean up operations over the hand labor method now used remains to be seen.

1954

ANNUAL CONVENTION
and
IRON AND STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ENGINEERS
CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

September 28, 29, 30, October 1

AN INVITATION TO STEEL MEN—

It gives me great pleasure to be able to extend to the members and friends of the Association of Iron and Steel Engineers a most cordial invitation to attend the 1954 Iron and Steel Exposition and AISE Annual Convention.

The papers which form the technical program have been prepared by authors well qualified to discuss the various topics. The exhibits, more than ever, will be educational and informative. The combined activities form a jack-pot of ideas to keep steel plant personnel in step with the competitive conditions prevalent in today's operations.

Make it a point to attend and, bring your associates.

E. L. Anderson
President, AISE

PREVIEW

IRON AND STEEL EXPOSITION

AISE

ANNUAL CONVENTION

▲Cleveland, Ohio
September 28, 29, 30, October 1.

Again, the Iron and Steel Exposition and AISE Convention, but this year bigger and better than ever before.

The return of the buyer's market is leading manufacturers of equipment and supplies to new designs, improved products — items that will help to reduce costs, save material, raise efficiency. More than 200 exhibitors will fill three halls of the Cleveland Public Auditorium with displays of these items to be viewed by approximately 15,000 engineers and operators of the iron and steel and allied industries. These industries will benefit materially from these demonstrations.

Indicative of the value of the Iron and Steel Exposition is an announcement issued by the British Board of Trade, quoting a United Kingdom manufacturer as saying the 1952 Exposition was of "primary importance," and further quoting the Cleveland Consulate as saying that the 1954 show "should not be missed by any representatives of United Kingdom firms interested in medium or heavy machinery who may be visiting the United States at the time of the show."

The technical program of the Annual Convention has also been expanded to include 16 sessions — 48 papers discussing topics of interest to steel plant personnel in every department prepared by authorities in their fields.

The program is arranged to enable every individual to hear the subjects in which he is particularly interested, and yet have ample time to study the exhibits. Technical papers and exhibits are geared to the man in the plant as well as to top supervision. It has often been said that no man can participate in the Exposition and Convention activities without picking up at least one idea that will help in his work.

Tickets for the 1954 Iron and Steel Exposition are being distributed throughout the iron and steel and allied industries. They may also be obtained, upon request, from the Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh 22, Pa. AISE membership is not required, and there is no registration fee either for the Exposition or for the technical sessions.

HOTEL RESERVATIONS

Arrangements have been made with Hotels Statler, Cleveland and Hollenden whereby they have set aside blocks of rooms for the use of those attending the convention and exposition of the Association of Iron and Steel Engineers in Cleveland, Ohio, September 28, 29, 30, and October 1, 1954.

We suggest that you make your reservation as early as possible, directly to the hotel of your choice. If that hotel cannot take care of you, they will pass your reservation on to the Cleveland Convention Bureau, who will place you elsewhere.

Be sure to state specifically the type of accommodations desired and the time of your arrival.

New developments, new designs, new applications are to be seen in the Exposition . . . .

. . . . and discussed in technical meetings.

A regular feature of the Convention is the annual dinner, which will be held in the ball rooms of Hotel Statler.

In no other place is there such a concentration of equipment and product displays of interest to the iron and steel industry . . . .

. . . . and in no other place is there such a concentration of steel industry personnel looking for new ideas.

PROGRAM

1954 AISE CONVENTION and IRON AND STEEL EXPOSITION

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CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

Tuesday, September 28

9:00 am—REGISTRATION—Main Lobby

9:15 am—BUSINESS MEETING—Ball Room

Conducted by President E. L. Anderson

9:30 am—ELECTRICAL SESSION—Ball Room

Chairmen: D. C. McCrady, Superintendent Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada
Arthur B. Glover, Superintendent Electrical Div., Acme Steel Co., Chicago, Ill.

"Power and Control Cables for Steel Mills," by E. D. Youmans, Vice President in Charge of Research and Product Development, The Okonite Co., Passaic, N. J.

"Methods for Locating Faults on Electrical Cables," by Mount Fitzpatrick, Cable Plant Engineer, Duquesne Light Co., Pittsburgh, Pa.

"Communications in the Steel Industry," by T. E. Hughes, General Foreman, Electric Shops and Motor Rooms, Homestead District Works, United States Steel Corp., Munhall, Pa.

9:30 am—BLAST FURNACE SESSION—Club Room B

Chairmen: C. G. Hogberg, Assistant Chairman—Operating Committee, United States Steel Corp., Pittsburgh, Pa.
W. H. Collison, Assistant General Superintendent, Blast Furnace Div., Great Lakes Steel Corp., Ecorse, Mich.

"Rapid Method of Relining a Blast Furnace," by Bruno Vezzani, Works Engineer, Donora Steel and Wire Works, American Steel and Wire Div., United States Steel Corp., Donora, Pa.

"Developments in Extending Blast Furnace Stack Life After Appearance of Hot Spots," by R. W. Sundquist, Assistant Division Superintendent Blast Furnaces, United States Steel Corp., Gary, Ind.

"The Venturi Washer for Blast Furnace Gas," by J. E. Eberhardt, Division Head, and H. S. Graham, Engineer, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

2:00 pm—MECHANICAL SESSION—Club Room B

Chairmen: E. C. Hite, Assistant Superintendent Maintenance, The Timken Roller Bearing Co., Canton, Ohio.
C. W. Bruce, Chief Engineer, Republic Steel Corp., Chicago, Ill.

"Re-Use of Industrial Cooling Water — Why and How," by Howard E. Degler, Technical Director, The Marley Co., Kansas City, Mo.

"Controlling Losses From Fire," by C. V. Batley, Insurance Surveyor, Bethlehem Steel Co., Bethlehem, Pa.

"Maintenance of Mobile Equipment," by Frank C. Wier, Superintendent Material Handling, and John C. Lantz, Maintenance Foreman, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

2:00 pm—COMBUSTION SESSION—Ballroom

Chairmen: E. H. Cauger, Assistant General Manager, Wheeling Steel Corp., Steubenville, Ohio.
H. W. Clark, Open Hearth Metallurgist, Ford Motor Co., Dearborn, Mich.

"Developments in Design of Modern Open Hearths," by Jay J. Seaver, Manager, Jay J. Seaver Engineers, Chicago, Ill.

"Some Aspects of Open Hearth Waste Gas Analysis Control," by F. P. Hubbell, Superintendent Fuel Dept., Homestead District Works, United States Steel Corp., Munhall, Pa.

"DSC's Multiple-Fueled Soaking Pits," by F. C. McGough, Superintendent of Fuel and Power, Detroit Steel Corp., Portsmouth, Ohio.

10:00 pm—PRESIDENT'S DANCE—Euclid Ball Room—Hotel Statler

Wednesday, September 29

9:00 am—ELECTRICAL SESSION—Ball Room

Chairmen: K. L. Johannsen, Division Superintendent Maintenance and Utilities, United States Steel Corp., Fairless Hills, Pa.
R. J. Beeswy, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.

"Improvement in High Capacity Industrial Third Rail Systems," by H. Yale Mageoch, Chief Engineer, Electric Service Manufacturing Co., Philadelphia, Pa.

"Taper vs Straight Tread Crane Wheels," by J. A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Protective Devices on Ore and Coal Bridges," by S. Tatalovich, Electrical Engineer, Heyl and Patterson, Inc., Pittsburgh, Pa.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.
F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

"Rate of Heat Absorption of Steel. Furnace Performance Test Data Compared to Simplified Theoretical Calculations," by Fred S. Bloom, President, Bloom Engineering Co., Inc., Pittsburgh, Pa.

"A Continuous Batch Type Annealing Furnace," by Ralph H. Gelder, Works Metallurgist, and Walter E. Hand, Supervising Metallurgist, Ashland Works, Armco Steel Corp., Ashland, Ky.

"Applications of High Velocity Combustion to the Steel Industry," by Leonard C. Peskin, President, Thermal Research and Engineering Corp., Conshohocken, Pa.

2:00 pm—STEELMAKING SESSION—Ball Room

Chairmen: Robert Sergeson, Chief Metallurgical Engineer, Rotary Electric Steel Co., Detroit, Mich.
A. K. Blough, Superintendent No. 2 and 3 Melt Shops, Republic Steel Corp., Canton, Ohio.

"A New Way to Control Arc Furnaces," by Charles W. Vokac, Manager Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.

"The Economic Aspects of the Oxygen Process," by W. C. Rueckel, Vice President, and J. W. Irvin, Associate Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

"Ferro-Manganese Additions in Open Hearth Steelmaking," by Rudolph Tietig, Jr., Engineer, A. J. Boynton and Co., Chicago, Ill.

Exposition and Technical Sessions are at Cleveland Public Auditorium . . . .

2:00 pm—LUBRICATION SESSION—Club Room B

Chairmen: N. I. Whiteley, Lubrication Engineer, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio.
W. M. Schuck, Lubrication Engineer, Armco Steel Corp., Middletown, Ohio.

"Non-Flammable Hydraulic Fluids as Applied to the Steel Industry," by C. R. Schmitt, Manager, National Lubrication Sales, E. F. Houghton and Co., Philadelphia, Pa.

"Stability of Lubricating Greases in Centralized Lubricating Systems," by E. L. Armstrong, Research Associate, and C. D. Thayer, Senior Technologist, Technical Service Dept., Socony-Vacuum Laboratories, Brooklyn, N. Y.

"What Type of Grease for that Application?," by W. A. Magie, II, Vice President, Magie Brothers Oil Co., Chicago, Ill.

6:00 pm—OLD TIMERS DINNER—The Hermit Club—1629 Dodge Court

Thursday, September 30

9:00 am—ELECTRICAL SESSION—Ball Room

Chairmen: Ray T. Winterringer, Assistant Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.
A. J. F. MacQueen, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada.

"Design and Construction of Transformers for the Steel Industry," by W. Walter Renberg, Jr., Electrical Power Design Engineer, Pennsylvania Transformer Co., Canonsburg, Pa.

"Kilovar, Kilowatt and Voltage Control in the Steel Plant," by L. G. Levoy, Industrial Power Engineer, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

"Synchronous Condensers for Steel Mill Service," by E. I. Pollard, Chief Electrical Engineer, Elliott Co., Ridgway, Pa.

9:00 am—LUBRICATION SESSION—Club Room B

Chairmen: C. T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.
D. N. Evans, Assistant Master Mechanic, Inland Steel Co., East Chicago, Ill.

"Modern Techniques of Lubrication Applied to Old Mill Equipment," by E. G. Weimer, Superintendent Primary Mills Maintenance, United States Steel Corp., Youngstown, Ohio.

"Bearing Maintenance for Economy," by John A. Toth, Assistant General Manager, Bantam Bearings Div., The Torrington Co., South Bend, Ind.

"Antidotes for Sleeve Bearing Failures," by Anthony F. Kaminskas, Product and Field Engineer, Cleveland Graphite Bronze Co., Division of Clevite Corp., Cleveland, Ohio.

2:00 pm—PROTECTIVE COATING SESSION—Club Room B

Chairmen: D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.
J. B. Whitlock, General Maintenance Engineer, Armco Steel Corp., Middletown, Ohio.

"Maintenance Painting in the Steel Industry," by Cecil Schofield, Director of Laboratories, Process and Product Development Div., Republic Steel Corp., Cleveland, Ohio.

"The Use of Heavy Cutback Asphaltum Mastic Coatings in Coke Plant Areas," by A. H. Bagenstose, Jr., Eastern Regional Manager, Insul-Mastic Corp. of America, Pittsburgh, Pa.

"Color, The Second Value in Paint," by N. A. Mason, Manager Maintenance Paint Sales, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

2:00 pm—OPERATING PRACTICE SESSION—Ball Room

Chairmen: George I. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
S. O. Evans, Chief of Engineering, Tubular Products Div., Babcock and Wilcox Co., Beaver Falls, Pa.

"Continuous Casting at Atlas Steels Ltd.," by John F. Black, Manager Continuous Casting Section, Koppers Co., Inc., Pittsburgh, Pa.

"Hot Skin Scarfing With a Mechanical Bloom Turner," by A. B. Glossbrenner, Assistant General Foreman, Bloom Conditioning Dept., Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

"Titanium: Its Progress and Its Applications," by T. E. Perry, Metallurgical Dept., and R. J. Garmy, Engineering Dept., Central Alloy District, Republic Steel Corp., Massillon, Ohio.

7:00 pm—FORMAL DINNER AND DANCE—Ball Rooms—Hotel Statler

Friday, October 1

9:00 am—ROLLING MILL SESSION—Ball Room

Chairmen: Alex Montgomery, Jr., Assistant to Vice President—Rolling, United States Steel Corp., Pittsburgh, Pa.
Wade Hoffman, Superintendent Roll Shop, Jones and Laughlin Steel Corp., Aliquippa, Pa.

"Cold Roll Forming," by Elmer J. Vanderploeg, Chief Engineer, The Yoder Co., Cleveland, Ohio.

"A-2 11-in. Rod Mill, Jones and Laughlin Steel Corp.," by N. A. Hansen, Superintendent, Rod and Wire Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

"Causes of Roll Breakage," by Charles F. Peck, Jr., Assistant Professor, and F. T. Mavis, Professor and Head, Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: E. T. Mortson, Superintendent Power and Fuel, National Tube Div., United States Steel Corp., McKeesport, Pa.
R. A. Lambert, Superintendent Steam and Combustion, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"New Power, Steam and Blowing Installations at Ohio Steel Works," by J. P. Katzenmeyer, Project Engineer, United States Steel Corp., Youngstown, Ohio.

"A Power Plant Report to Management," by Stanley A. Nelson, Supervisor of Plant Engineering, Deere and Co., Moline, Ill.

"The Effect of Changes in Gas Composition on the Utilization of Fuel Gases," by Edwin X. Schmidt, Development Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

2:00 pm—ELECTRICAL SESSION—Ball Room

Chairmen: E. F. Donatic, Assistant General Superintendent, Service Div., Kaiser Steel Corp., Fontana, Calif.
R. T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton, W., Va.

"Operation of Magnetic Amplifier Controlled Tandem Mills," by J. W. Brinks, Steel Mill Engineer, Westinghouse Electric Corp., and J. C. Peth, Chief Electrical Engineer, Pittsburgh Steel Co., Monessen, Pa.

"Maintenance and Repair Experience with Various Hydraulic Systems on Charging Machines and Manipulators," by Robert S. Bogar, Assistant Chief Engineer, Bethlehem Steel Co., Johnstown, Pa.

"A New Design Concept for D-C Motors," by William R. Hough, Engineering Vice President, and R. A. Geuder, Manager, Industry Sales, Reliance Electric and Engineering Co., Cleveland, Ohio.

2:00 pm—OPERATING PRACTICE SESSION—Club Room B

Chairmen: Leonard Larson, Chief Engineer, Corrigan-McKinney Works, Republic Steel Corp., Cleveland, Ohio.
George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

"Pinholes in Steel Sheet and Pinhole Detecting Apparatus," by George H. Rendel, Research Associate, Research and Development Laboratory, United States Steel Corp., Pittsburgh, Pa.

"Continuous Drawing of Cold Finished Bars," by Walter J. Prochak, Assistant Superintendent, Cold Drawn Bar Dept., Youngstown Sheet and Tube Co., Youngstown, Ohio.

"Ten Years of Mechanical Descaling of Hot Rolled Steel Products," by Gilbert D. Dill, Engineer in Charge of Steel Div., American Wheelabrator and Equipment Corp., Mishawaka, Ind.

Social Functions are at Hotel Statler . . .

Iron and Steel Exposition Hours

September 28—Tuesday, 10:00 am - 10:00 pm
September 29—Wednesday, 10:00 am - 10:00 pm
September 30—Thursday, 10:00 am - 5:30 pm
October 1—Friday, 10:00 am - 4:00 pm

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NO REGISTRATION FEE

LADIES PROGRAM

HEADQUARTERS

PARLOR E

HOTEL STATLER

TUESDAY, September 28

9:00 am — Ladies Registration — Parlor E, Hotel Statler

12:00 noon — Luncheon — Euclid Ball Room, Hotel Statler

Music — Entertainment — Door Prizes

10:00 pm — President's Dance — Euclid Ball Room, Hotel Statler

WEDNESDAY, September 29

12:30 pm — Luncheon — Acacia Country Club

Buses to leave Hotel Statler 11:30 am (Ladies meet in Parlor E, Hotel Statler)

THURSDAY, September 30

7:00 pm — Formal Dinner — Ball Rooms, Hotel Statler

10:00 pm — Dance — Euclid Ball Room, Hotel Statler

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General Chairwoman — Mrs. Leonard Larson

Vice Chairwoman— Mrs. H. L. Jenter

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To partially cover costs of ladies activities, a flat charge of $5.00 will be made for the luncheons on Tuesday and Wednesday. This must be paid on registering, when tickets will be issued for these events.

Cleveland, Ohio, near the center of the steel industry, is within a day's drive of about 70 per cent of the iron and steel industry.

BIGGER THAN EVER BEFORE IN 1954

IRON and STEEL EXPOSITION

CLEVELAND

September 28, 29, 30, October 1

LIST OF EXHIBITORS

A

ACF Industries, Inc.
Adalet Manufacturing Co.
Ajax Flexible Coupling Co., Inc.
Alemite Division, Stewart-Warner Corp.
Allen-Bradley Co.
Alliance Machine Co.
Allis Co., Louis
Allis-Chalmers Manufacturing Co.
American Air Filter Co., Inc.
American Brake Shoe Co.
American Flexible Coupling Co.
American Forge and Manufacturing Co.
American Wheelabrator & Equipment Corp.
Ampco Metal, Inc.
Apparatus Sales Division, General Electric Co.
Appleton Electric Co.
Askania Regulator Co.
Atlas Mineral Products Co.
Automatic Transportation Co.

B

Bailey Meter Co.
Bantam Bearings Division, The Torrington Co.
Bearing Service Co.
Blaw-Knox Co.
Bliss Co., E. W.
Bloom Engineering Co., Inc.
Bowser, Inc.

C

C & D Batteries, Inc.
Cardox Corp.
Chandeysson Electric Co.
Chromium Corp. of America
Cities Service Oil Co.
Clark Controller Co.
Clark Equipment Co.
Cleveland Worm & Gear Co.
Cooper Split Roller Bearing Corp.
Crouse-Hinds Co.
Cunningham Co., M. E.
Cuno Engineering Corp.
Curry Air Shear Corp.
Cutler-Hammer, Inc.

D

DeLaval Separator Co.
Delpark Corp.
Delta-Star Electric Division, H. K. Porter Co.
Diamond Power Specialty Corp.
Dowell Incorporated
Down River Casting Co.
Dravo Corp.
Drever Co.

E

Electric Controller & Manufacturing Co.
Electric Furnace Co.
Electric Products Co.
Electric Service Manufacturing Co.
Electric Storage Battery Co.
Elliott Co.
Elwell & Co., R. A.
Elwell-Parker Electric Co.
Enterprise Co.
Euclid Electric & Manufacturing Co.

F

Factory Stores
Farmers Engineering & Manufacturing Co.
Farval Corp.
Federal Electric Products Co.
Foxboro Co.
Frazier-Simplex, Inc.

G

Garlock Packing Co.
General Electric Co., Apparatus Sales Division
General Electric Co., Trumbull Components Department
Gleason Reel Corp.
Gould-National Batteries, Inc.
Gulf Oil Corp.
Guyan Machinery Co.

H

Hagan Corp.
Harman Associates, F. Ward
Harnischfeger Corp.
Heil Process Equipment Corp.
Heli-Coil Corp.
Heyl & Patterson, Inc.
Holophane Co., Inc.
Homestead Valve Manufacturing Co.
Houghton & Co., E. F.
Hunt & Son, Inc., C. B.
Hyatt Bearings Division, General Motors Corp.
Hyde Park Foundry & Machine Co.

I

Ideal Industries, Inc.
Industrial Filtration Co. & Delpark Corp.
Industrial Nucleonics Corp.
Insul-Mastic Corp. of America
Iron Age
Iron Lung Ventilator Co.
I-T-E Circuit Breaker Co.

J

Johns-Manville Sales Corp.
Joy Manufacturing Co.

K

Karlson Co., K. E.
Kennametal, Inc.
Kinney Engineers, Inc., S. P.
Koppers Co., Inc.

L

Lake Shore Electric Corp.
Leeds & Northrup Co.
Linde Air Products Co., Division of Union Carbide & Carbon Corp.
Link-Belt Co.
Lintern Corp.
Loftus Engineering Corp.

LIST OF EXHIBITORS (continued)

M

Machinery Division, Blaw-Knox Co.
Manco Manufacturing Co.
Manning, Maxwell & Moore, Inc., Shaw Box Crane & Hoist Division
Markal Co.
Martindale Electric Co.
Matthews & Co., Jas. H.
McDowell Co., Inc.
Medart Co.
Mesta Machine Co.
Metal Carbides Corp.
Metalmaster Division, Clinton Machine Co.
Mine Safety Appliances Co.
Minneapolis-Honeywell Regulator Co., Industrial Division
Morgan Construction Co.
Morgan Engineering Co.

N

National Alloy Steel Division, Blaw-Knox Co.
National Carbon Co., Division Union Carbide & Carbon Corp.
National Electric Coil Co.
National Industrial Publishing Co.
Nelson Stud Welding

O

Ohio Carbon Co.
Ohio Electric Manufacturing Co.
Okonite Co.
O. Z. Electrical Manufacturing Co., Inc.

P

Pannier Corp.
Penton Publishing Co.
Plasteel Products Corp.
Poole Foundry & Machine Co.
Porter Co., H. K., Delta-Star Electric Division
Porter-Cable Machine Co.
Post-Glover Electric Co.
Pratt & Whitney, Division Niles-Bement-Pond Co.
Pyle National Co.

R

Radiant Lamp Corp.
Ramtite Co.
Ready-Power Co.
Red Seal Electric Co.
Reintjes Co., George P.
Reliance Electric & Engineering Co.
Relsid Equipment Co.
Republic Flow Meters Co.
Robertson Co., H. H.
Robinson Pipe Cleaning Corp.
Robinson Ventilating Co.
Rockbestos Products Corp.
Roller-Smith Corp.
Rolls Division, Blaw-Knox Co.
Rollway Bearing Co., Inc.
Rome Cable Corp.
Rowan Controller Co.
Rust-Oleum Corp.

S

Salem-Brosius, Inc.
Selas Corp. of America
Sheffield Corp.
Shell Oil Co.
Signode Steel Strapping Co.
Simplex Wire & Cable Co.
SKF Industries, Inc.
Socony-Vacuum Oil Co., Inc.
Solvent Service, Inc.
Speer Carbon Co.
Spraying Systems Co.
Square D Co.
Steel City Electric Co.
Stoody Co.
Superior Carbon Products, Inc.
Sutton Engineering Co.

T

Taylor Chain Co., S. G.
Texas Co.
Thompson Electric Co.
Timken Roller Bearing Co.
Tool Steel Gear and Pinion Co.
Torrington Co., Bantam Bearings Division
Trabon Engineering Corp.
Treadwell Construction Co.
Trumbull Components Department, General Electric Co.

U

Union Carbide & Carbon Corp.
Union Steel Castings Division, Blaw-Knox Co.

V

Valvair Corp.
Velan Engineering, Ltd.

W

Wachs Co., E. H.
Wagner Electric Corp.
Waldron Corp., John
Wean Engineering Co., Inc.
Webb Co., Jervis B.
Wellman Engineering Co.
Westinghouse Electric Corp.
Wilson Engineering Co., Inc., Lee
Wing Manufacturing Co., L. J.

X-Y-Z

Yale and Towne Manufacturing Co.
York-Gillespie Manufacturing Co.
Zurn Mfg. Co., J. A.

IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

ASSOCIATION of IRON and STEEL ENGINEERS

1010 EMPIRE BUILDING · PITTSBURGH 22, PA.

AIR POLLUTION CONTROL in the Bethlehem Steel Company

. . . . air pollution is a price which must be paid for the benefits derived from our industrial economy . . . . with time, industry is gradually finding ways to lower the price . . . .

By ALLEN D. BRANDT
Chief Industrial Hygiene Engineer
Bethlehem Steel Co.
Bethlehem, Pa.

▲ IN discussing the subject of air pollution control in the Bethlehem Steel Co., it will be less confusing if we select a typical plant of the company and confine the remarks to the operations at that plant insofar as possible than to skip helter-skelter from one plant to another. No two of the company's plants are strictly alike either as to end products manufactured or as to major sources of air pollution. Consequently, this paper will outline the control program at our largest plant located at Sparrows Point, Md., except for those operations constituting major air pollution sources not found at this plant.

The current annual steelmaking capacity of the Sparrows Point plant is nearly 6,000,000 tons. To produce this quantity of steel requires about 7,200,000 tons of iron ore, 2,000,000 tons of scrap, 4,500,000 tons of coal and 2,000,000 tons of limestone.

THE PROBLEM

Before discussing what is done in the way of air pollution control at our Sparrows Point plant, let us start at the beginning by reviewing briefly the problem. Steelmaking for the most part is one series of metallurgical operations carried on at high temperatures. Large quantities of solid, liquid and gaseous fuels are burned, and significant amounts of the process ingredients find their way into the air or gas streams which are a necessary part or ingredient of the process. For example, about eight tons of air enters into the making of one ton of steel. Converted to more meaningful terms, air is used at the rate of about 2,500,000 cfm at Sparrows Point. Some of this air becomes heavily laden with iron and its oxides by the time it has served its primary function in the process, other portions with sulphur compounds, and still others with a multitude of contaminants both gaseous and solid. Air pollution control in steel plants, then is directed at (1) removing most of the objectionable impurities from the air or gas discharged to the outside, and (2) keeping to a minimum the escape of pollutants from other miscellaneous or unpreventable sources.

COKE OVENS

Conventional coke ovens in steel plants release extremely minute amounts of impurities to the air by comparison with the now almost obsolete beehive ovens. The volatile matter (gases, liquids and solids) given off from the coal during the coking process is collected in a piping system and recovered in the by-products plants in the form of tar, benzene, toluene, naphtha, naphthalene, pyridine, ammonium sulphate, and other commercial products. These chemicals or their intermediates were allowed to escape into the atmosphere by the beehive coking procedure, but it is now essentially standard practice to recover them. The cleaned coke gas, which is very high in hydrogen and methane, is an excellent fuel and is used in the plant for this purpose or is sold. It is not important as regards air pollution at Sparrows Point although it may be at some steel plants.

Much of the sulphur in the coking coal finds its way into the coke gas in the form of H_2S. When the gas is burned, SO_2 is formed and may create a problem depending upon the geography, meteorology, and nearness of the furnace stacks to houses, sensitive vegetation, and the like. Even though the sulphur dioxide from the coke gas fuel consumed in the plant at Sparrows

It is an extremely difficult problem, one perhaps impossible of solution, to eliminate smoke from large, integrated steel plants. In the cases where there is a feasible engineering solution, costs may be insurmountable.

Point has not been troublesome air pollution-wise, metallurgical considerations and the need for sulphuric acid make it advisable to desulphurize much of the gas and to manufacture sulphuric acid from the sulphur removed. Consequently, a sulphuric acid plant was constructed recently and is now in operation. This plant produces about 50 tons of sulphuric acid per day. The H_2S content of the cleaned gas is thereby reduced to about 0.7 gr/cu ft from an average content of 4.5 gr/cu ft.

There is, however, one air pollution problem in the usual operation of the coke ovens which has not yet been solved satisfactorily. This is the brown or black smoke which escapes from the ovens while they are being charged. The amount of smoke escaping can be kept small enough by careful operation to be unobjectionable but it cannot be eliminated. This is one of the few air pollution problems in a steel plant for which a satisfactory solution is not yet available. Fortunately, some of the more down-to-earth ordinances take cognizance of this difficulty and provide accordingly. Badly fitted or improperly sealed oven doors may permit considerable smoke to escape, but this is merely a matter of proper maintenance and operation.

BLAST FURNACES

The blast furnaces account for roughly one-third of the air entering steel manufacturing processes. As this gas leaves the furnaces, it is heavily laden with solid impurities, mostly iron oxide. However, blast furnace gas cleaning is an old and well established art with the result that the gas commonly referred to as raw gas in the steel industry has been through two cleaning operations and has had more than 99 per cent of its dust burden removed. It has long been the practice to clean some of the blast furnace gas even further before using it. This was done by means of wet type collectors commonly called disintegrators. At present much of the gas is given a final cleaning treatment in electric precipitators which remove all but a trace of the solid impurities.

Blast furnace gas is very high in carbon monoxide. Hence the small portion of it which must be bled to the atmosphere is burned to get rid of this gas.

As with coke ovens, blast furnace operation presents an erratic air pollution problem which is neither preventable nor controllable in the present state of the art. Occasionally the furnace burden will shift irregularly or slip resulting in a violent rush of gas into the piping system. Such slips sometimes develop greater pressure in the furnace and piping system than can be handled safely. To prevent damage, huge valves high on the furnace open to permit the escape of some of the gas until the pressure returns to a safe operating level. This procedure releases clouds of dust-laden gas to the atmosphere. A completely satisfactory solution to this problem is not in sight at present. More careful furnace operation and control supported by improved instrumentation goes a long way toward preventing slips. Improvements in the preparation of certain raw materials also assist in reducing the number of slips. As of today, however, blast furnace slips occur occasionally and pose a problem to the steel industry and to air pollution control officials alike. Some of the more realistic authors of air pollution control ordinances have taken cognizance of this situation and provided for it in the regulations. Both geography and climate are kind to us at Sparrows Point so that the slips which do occur seldom are felt beyond the plant boundary.

SINTERING PLANT

The fines in blast furnace raw materials are a constant source of operational headaches and present an aggravated gas cleaning problem if not removed from the blast furnace burden before charging. For this reason it is the current practice to screen the fines from the materials charged to the furnaces. These fines, as well as those recovered in gas cleaners and dust collectors at the different metallurgical operations, are rich in iron and would represent a loss of a substantial amount of raw material if they could not be used in the blast furnaces. They can be adapted to blast furnace use by sintering, a process in which the fines are converted to a large size, very porous product which responds well to blast furnace processing. A sintering plant has

been constructed at Sparrows Point and was placed in operation about a year ago.

In the sintering process, air at the rate of more than 100,000 cfm per line is drawn across the belt or grate on which the burning or sintering is carried out. Since the raw materials are rich in fines as a rule, some of this material is entrained by the air stream before it becomes fused or otherwise fixed in the sinter cake. Conventional practice in the past has been to clean this air by means of large diameter cyclone separators. Such procedure fails to capture much of the very fine material. Consequently electric precipitators have been added to gas cleaning equipment in the stacks of our Sparrows Point plant. This reduces the dust loading in the discharged air from the sinter belts to about 0.01 gr/cu ft from 0.5 gr/cu ft which is the usual loading if cyclones only are used

There are other sources of air pollution at a sintering plant, the most important of which probably is the discharge end of the sinter belt. Here the sintered material which is still hot drops from the belt and slides down a chute. This end of the belt of most sintering lines is enclosed and vented to the outside by means of a large-diameter stack in which air flow is created by the heat of the sintered material. At the Sparrows Point plant the dust is removed from this air by means of small diameter cyclones before it is discharged to the outside.

OPEN HEARTHS

Open hearth furnaces constitute the major problem still unsolved, for the most part, in the steel-making industry. According to Bishop(1)* dust loadings in stack gases from these furnaces may go as high as two grains per standard cubic foot for momentary peaks during certain parts of the cycle. He reports the average concentration for the entire heat to be 0.43 gr per standard cubic foot. This dust burden is composed almost entirely of metallic oxides, about 90 per cent by weight being iron oxide. It is extremely fine; one report(1) being that about 50 per cent by weight is smaller than 5 microns, and another (2) that the mean particle diameter is 0.5 microns with no particles above 3 microns. Since the weight of any particle of a given substance increases as the cube of the diameter, it is apparent that on a number basis an overwhelming proportion of the solid particles in open hearth stack gases are less than one micron in size. To illustrate this point more forcefully, let us assume that the 50 per cent of the material larger than 5 microns(1) is actually all twice that size or 10 microns, and the 50 per cent smaller is half the stated size or 2.5 microns. By number, 98.5 per cent of the particles are 2.5 microns and 1.5 per cent are 10 microns. While this represents a highly artificial condition as to dust distribution, we find the condition illustrated to be borne out in practice. In a recent study of stack gases from a metallurgical furnace where the collector in the stack was selective as to particle size, we found the filtering efficiency by weight was about 49 per cent and by number was about 2 per cent. Obviously, then, to be satisfactory a collector for open hearth fumes and dust must have a high collecting efficiency against extraordinarily small particles.

*See Bibliography at end of article.

In addition to the fineness of the solid pollutants in open hearth stack gases, one other feature adds to the collector design difficulty. This is excessive temperature. Only two types of collectors available today have the dust collecting characteristics required to clean open hearth gases effectively. These are fabric filter collectors commonly called "bag houses" and electric precipitators. The high temperature of the gases precludes the use of fabric filter collectors unless the gas temperature is reduced a great deal by appropriate heat exchangers. This difficulty has loomed so great up to the present as to discourage research in this direction. Specially designed precipitators have been installed in a few open hearth stacks in this country rather recently. Only time will tell whether this is the answer. There is great need both for research into the fundamentals of separating particulate matter from gas streams, and for applied research on modified versions of equipment now available if a feasible solution is to be found to the open hearth problem.

ELECTRIC FURNACES

We do not have electric furnaces at Sparrows Point, but do have at several other plants including Los Angeles and will transfer to that plant for this part of the discussion. The three large furnaces at this plant are equipped with humidifying towers and precipitators for cleaning the gases of their dust and fume burden. Several years ago when these furnaces first were installed, they were equipped with electric furnace hoods in the shape of inverted frying pans directly above and forming an integral part of the furnaces and with a type of wet collector which in the opinion of the Los Angeles County Air Pollution Control officials would be satisfactory. These collectors proved to be far from satisfactory and electrostatic precipitators were installed, and even these were a long way from meeting Los Angeles County Ordinance requirements. Auxiliary equipment in the form of huge spray towers for humidification of the gases prior to entering the precipitators was then added. This improved the collecting efficiency of the precipitators sufficiently to meet the ordinance requirements.

However, the original hoods were an unending source of trouble of various and sundry kinds. The hoods were eliminated recently in favor of taking the gases directly from the furnaces through ducts connected to the roofs of the furnaces. This created some problems in metallurgy, but apparently these have been solved satisfactorily and the smoke, dust and fumes at these electric furnaces are being removed very effectively from the furnace gases at all times except when charging. The furnaces are of the top charging type and the exhaust system is inoperative when the top of the furnace is removed for charging. Even though considerable dust and smoke rise from the furnaces during charging operations, these constitute such a small part of the total operating time as to be of relatively little significance.

BESSEMER CONVERTERS

Only a very small percentage of the steel made in the United States today is produced by the bessemer process. At Sparrows Point, for example, there are three

bessemer converters which contribute only about 7 per cent of the steel made at this plant. It may be said without fear of contradiction that from the mechanical standpoint, air pollution control at bessemers is the most difficult single problem in the steel industry. Anyone with a sound solution to this problem can endear himself to many by making the answer known.

POWER PLANTS

Power plants burning solid fuel in steel plants have no problems that are different from power plants elsewhere. Many such plants have collectors in the stacks, although some of the older ones do not. Electric precipitators are rare, the more common type of collector found on such stacks is the dynamic precipitator.

MISCELLANEOUS

There are other individual sources of air pollution in a steel plant but individually or in toto they are minor by comparison with those already discussed. The practice as to air pollution control at these sources varies from plant to plant. At Sparrows Point, for example, we have cyclones on some of the coal crushing operations in the coal handling plant; filter fabric collectors on certain foundry operations, and cyclones on others; spray scrubbers on pickling or cleaning tanks; and a dynamic precipitator on the exhaust from the pipe galvanizing operations, to mention but a few.

AIR POLLUTION INVESTIGATIONS

Air pollution investigations including stack sampling are not a "hit or miss" arrangement in the Bethlehem Steel Co. The combustion or fuel department of each plant carries out studies of this nature routinely at the different steel-making plants. New types of collectors are tested under the supervision of research department. This work is supplemented and the overall program for all plants, mines and shipyards is coordinated by personnel in the company industrial hygiene department. One chemical engineer with long experience in air pollution matters and one meteorologist devote full time to air pollution investigations and control problems, and the others in this department give of their time as required to air pollution studies.

We can hardly deny that the Bethlehem Steel Co. has problems in air pollution which remain unsolved at this time. These problems are being brought under control one by one as new advances in technology furnish satisfactory solutions and as time, men, material and opportunity permit. Great strides have been made since the war and even greater ones are in prospect for the near future. We who are engaged in this great movement and even, more so, the public generally, should not lose sight of one fundamental and tremendously important fact. The increase in air pollution in this country during recent decades is a by-product of the vast industrial expansion which in turn has given us a standard of living that is the envy of all other countries. This is not an attempt to excuse our shortcomings in this respect, but rather to show that the inconvenience of increased air pollution is not without its compensations. According to published data which came to our attention recently, there were 3300 lb of steel per capita in the U.S.A. in 1900, and in 1950 this figure had increased to 14,500 lb per capita. This increase brought with it an increase in air pollution, but it also brought refrigerators, automobiles, automatic kitchens, better highways and a multitude of other things.

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DISCUSSION

PRESENTED BY

BENJAMIN LINSKY, Chief Smoke Inspector, Bureau of Smoke Inspection and Abatement, City of Detroit.

ALLEN D. BRANDT, Chief Industrial Hygiene Engineer, Bethlehem Steel Co., Bethlehem, Pa.

J. A. SHIMMIN, Vice President in Charge of Operations, Rotary Electric Steel Co., Detroit, Mich.

A. O. MASON, Research Engineer, Ternstedt Div., General Motors Corp., Detroit, Mich.

CARL W. SISCO, Sales Engineer, Surface Combustion Corp., Toledo, Ohio.

Benjamin Linsky: I believe that the factual data presented in this paper is essentially right. I found no valid disagreements. Some of the editorial comments in the paper are, however, open to debate.

I am happy to learn that the sulphuric acid plant operation, where you are removing hydrogen sulphide is now in operation. I am sure this makes a difference in the neighborhood.

In discussing blast furnace slips, Mr. Smith, of the Kaiser Steel Co. plant in California, has informed us that they had been able to avoid all major slips for about four years. That does not mean that they have had no blast furnace slips, but they have been able to avoid major slips. I asked him how he accounted for this in their operation and design. He said he did not think it was design particularly. It was his feeling that their method of operation was primarily the cause of their being able to avoid major slips. He mentioned specifically double sizing of the ore as well as double sizing of the coke, keeping the bottom size of the size of the coke up, and sintering the ore fines to a point where there was less bridging and arching.

The figures on sinter plant emissions were the first ones I have ever seen published anywhere and were very interesting to us because there has been a lot of conjecture about it and no published measurements, to our knowledge, until this paper was presented.

The relatively new development of open hearth dust collectors at the Fairless plant is of interest, but I have not seen any further reports that give real values or conclusions on that point. I suppose they are still removing the bugs out of relatively new operations.

Mention was made of electric furnaces and of bag houses and the possibility that they may be more

useful than electrostatic precipitators for sub-micron dusts and fumes. I mentioned previously to Mr. Brandt that the Dodge-Winfield plant of the Chrysler Corp., in studying the problems of electric furnaces where they do continuous gray iron melting, have selected a cloth filter collector. This selection was made after extensive test work had been carried out by the Chrysler Corp., in which our bureau participated to a small degree.

I was fortunate in being able to see Bethlehem's electric furnace operation at Los Angeles when the equipment had been operating only about five days with the new dust exhaust system. At the time it looked good, and the plant management was hopeful that it would work. I am glad to hear this report that it has worked without major difficulties.

Bessemer converters still remain a problem. The German work on glare shielding, however, indicates that bessemer emissions can be ducted, and it would seem to us that any emission that can be ducted can be cleaned.

We are all probably more familiar with the control of emissions from power plants than any other single kind of operation. There are a lot of answers to such emissions except the sulphur dioxide which comes out of fuel burning, which does not appear to be a critical problem in this area. In a vegetation survey which has been made in the area, we looked for various kinds of air pollution damage to vegetation — sensitive vegetation — and we were pleased to find so little in most of the industrial area in and around Detroit.

Member: Have you found any tendency of fouling in the electrostatic precipitators?

Allen D. Brandt: Yes, we have encountered fouling of different kinds. If the air is too moist when it reaches the precipitator, the collected dust may form a mud and interfere with the operation of the precipitator. This is especially true if the dust is more or less hygroscopic and is present in high concentration. In some instances improper distribution of the air stream through the collector will result in low dust retention efficiency; a condition which might be classified as fouling. Fouling does occur on occasion, but usually can be prevented by proper maintenance.

Member: Do you use any high velocity jet-type collectors?

Allen D. Brandt: To the best of my knowledge, there is no high velocity jet type collector in production use in the Bethlehem Steel Co. We studied the characteristics of a full-scale model, but I do not believe we are using any.

J. A. Shimmin: What can you say about the cost of equipment and installation for gas and dust control on both electric arc and open hearth furnaces?

Allen D. Brandt: According to published reports, the precipitators on four open-hearth furnaces in a west coast steel plant cost a total of about $600,000 or an average of $150,000 per furnace. I have not heard or seen reported what the precipitators cost that were installed in an eastern steel plant.

As to electric furnaces, the total cost of the precipitators and accessory equipment for three electric furnaces in one of our west coast plants was close to $500,000.

Member: Please discuss methods of controlling electric furnace pollution in Los Angeles.

Allen D. Brandt: This point was covered briefly in the paper, insofar as our own electric furnaces are concerned. The important points on this installation may bear repeating. These are: (1) other collectors were tried before the precipitators were installed; (2) the precipitators were unsatisfactory until the auxiliary gas conditioning equipment was installed; (3) the auxiliary gas conditioning equipment was aimed at humidifying the gases, but it reduced the temperature also; and (4) the conventional electric furnace hoods were discarded in favor of direct exhaust from the furnaces through pipes installed in the furnace roofs.

I am not too well informed on what has been done on other electric furnaces in Los Angeles, but it is my understanding that bag house type collectors with appropriate auxiliary gas conditioning equipment have been installed at some such furnaces and are satisfactory.

Member: In Bethlehem's operation of blast furnaces with best controls, how many slips do you experience per day, month, year?

Allen D. Brandt: That is very difficult to say, because blast furnaces are temperamental, if you will pardon the use of that term. With good instrumentation and careful control, a blast furnace may go for days and days without a slip. Then, for no apparent reason, there may be several slips in one day. Even though there has been a tremendous improvement in this respect as to blast furnace operation in recent years, even today blast furnace operation is something of an art; it is not entirely a science. Whereas I do not have cold facts on this question, I can speak with some authority because until recently my office was on the tenth floor of an office building overlooking seven blast furnaces. In recent years it has been rare to see or hear a slip in any of these furnaces, yet occasionally, two or three may occur in one day in the same furnace.

Probably the best answer to the question is that a properly regulated and carefully operated blast furnace will rarely have a slip. It will go days on end without a slip, but occasionally may have several in one day.

A. O. Mason: Can you state the practical probabilities of the oxygen converter with glass cloth bag house from the point of view of air pollution?

Allen D. Brandt: Not having had any first hand contact with this problem, my answer must be in the nature of an opinion. If the gases to be cleaned are free from fluorides; the temperature of the gases does not exceed that which the glass bags in question will withstand; and the moisture content of the gas stream is not high enough to cause condensation on the particulate matter in the gas stream or on the filtering material in the bag house, there is no apparent reason why such collectors should not be entirely satisfactory.

Carl Sisco: Could you describe briefly a dynamic type cleaner?

Allen D. Brandt: The term "dynamic precipitator" is a generic one which applies to all cleaners that depend largely on the momentum of the particle in motion to effect separation from the gas stream. Examples are large and small diameter cyclones, and many other collectors which take advantage of the centrifugal force of the particulate matter to throw it out of the air stream as the direction of flow of the air stream is changed.

Recent Advancements in Continuous Butt and Induction Weld Pipe Mills

By WILLIAM RODDER

Vice President — Engineering, Aetna-Standard Engineering Co., Pittsburgh, Pa.

. . . . speeds of pipe mills have practically doubled in the past five years . . . . accomplishment is largely due to advancements in auxiliary equipment . . . .

▲THE advancements which have been made during the last five years in the design and construction of new continuous butt weld pipe mills have contributed materially to the following:

1. Production has been increased. In the smaller pipe sizes, production has been increased 100 per cent and more.
2. The increase in production has been obtained without increasing manpower of hot mill.
3. Quality of weld has been improved by increased reduction of pipe after weld has been made.

The following describes typical new mill layouts and changes in design of equipment which have made it possible to increase pipe speed from previous accepted speeds of approximately 500 fpm for ½-in. pipe to 1,000 fpm and higher.

The principal bottleneck which prevented an increase in speed and production in the past was the flying saw. The saw has to cut the pipe after it is delivered from the forming, welding, and reducing mill in predetermined lengths varying, depending on use of pipe, between 18 and 44 ft, the most common standard lengths cut being 21 ft for single length pipe and 42 ft for double length pipe.

If the mill is operating at a speed of 1050 fpm and 21 ft pipe lengths are required, the saw has to make 50 cuts per minute, equal to one cut every 1.2 seconds.

With the conventional reciprocating type stop and start saw, the practical limit of one cutting cycle was found to be approximately 2½ seconds, resulting in a pipe speed when cutting 21-ft lengths of 500 fpm. At this speed, on account of the high stresses imposed from accelerating and decelerating forces, the saw required close attention, good maintenance, and frequent overhauling.

The increased sawing speed was made possible by adopting a saw design where the saw blade travels continuously in a circular path. This design completely eliminates all accelerating and decelerating forces, wear and tear of equipment. Four years of continuous operation have proven that the maintenance and shut-down time are almost negligible.

The first of these type saws had the following capacity:

Pipe size	⅜ to 2-in.
Cutting range	18 to 54-ft
Maximum speed	1000 fpm

Actually, top speeds of 1100 fpm have been obtained. This top speed was limited by the heating capacity of the furnace and not by the saw.

Figures 1 and 2 show design of saw. Figure 3 shows the saw in operation. Figure 4 shows the cutting diagram.

The saw is designed for three cutting ranges:

1. One cut is made every second revolution of crank. Length of cut—18 to 27 ft.
2. One cut is made every third revolution of crank. Length of cut—27 to 40.5 ft.
3. One cut is made every fourth revolution of crank. Length of cut—36 to 54 ft.

Length of cut within each cutting range can be varied from operator's pulpit while mill is operating full speed. A dial is provided to show operator length of cut saw is making.

Gear shifts are provided to change saw from one cutting range to another—for this adjustment, saw must be momentarily stopped.

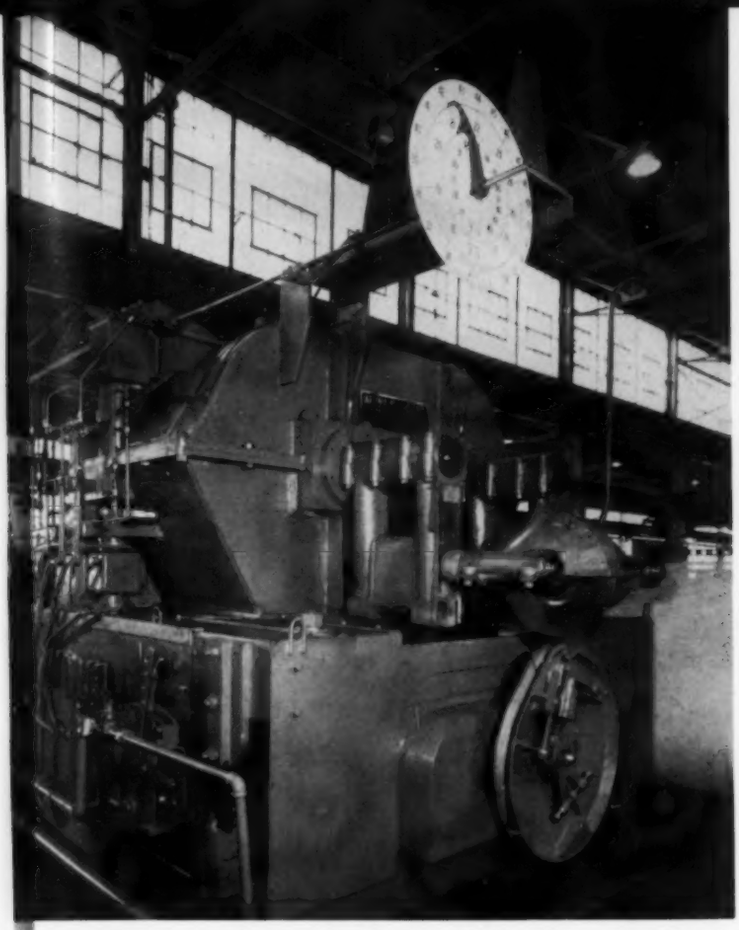


Figure 1 — Saw cuts pipe from ⅜ to 2-in. diameter in lengths from 18 to 54 ft.

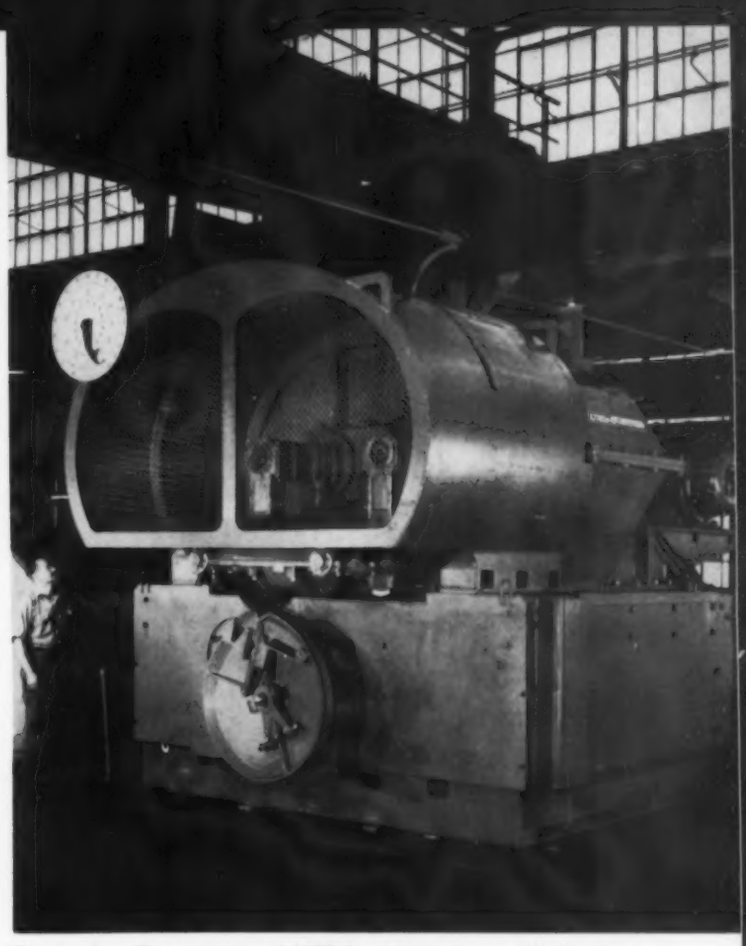


Figure 2 — Top speeds of 1100 fpm have been obtained on this saw.

So that linear speed of saw blade during cutting interval is synchronized with pipe speed, the travel of crank which carries saw carriage is maintained equal to length of pipe to be cut. When a cutting length variation is to be made, rpm of crank is changed simultaneously with crank radius so that linear speed of saw is maintained.

Whenever a cut is made, the pipe, by means of a rotating lower cutting cam, mounted on an eccentric, is deflected into the path of the saw blade travel.

Just recently, a new saw has been completed for cutting pipe sizes ⅜ to 4-in. Length of cut and cutting ranges are the same as for saw mentioned previously. Figure 5 shows design of this saw. Figure 6 shows cutting diagram for this saw.

This new design will fill a long desired demand for an efficient, high speed saw for mills having a capacity of ½ to 3-in. pipe sizes or ½ to 4-in. pipe sizes. This saw also has been designed for a maximum speed up to 1000 fpm.

In order not to deflect a 4-in. pipe the full diameter into the path of saw travel, an additional eccentric movement has been added to upper crank drive. See Figures 5 and 6.

While the cut is being made, the saw blade, by means of the upper eccentrics, is lowered into the path of pipe travel. At the same time, the pipe is lifted up by the lower eccentric and rotating cutting cam into the path of saw travel. During the cutting interval, a 4-in. pipe is lifted 2¼-in.

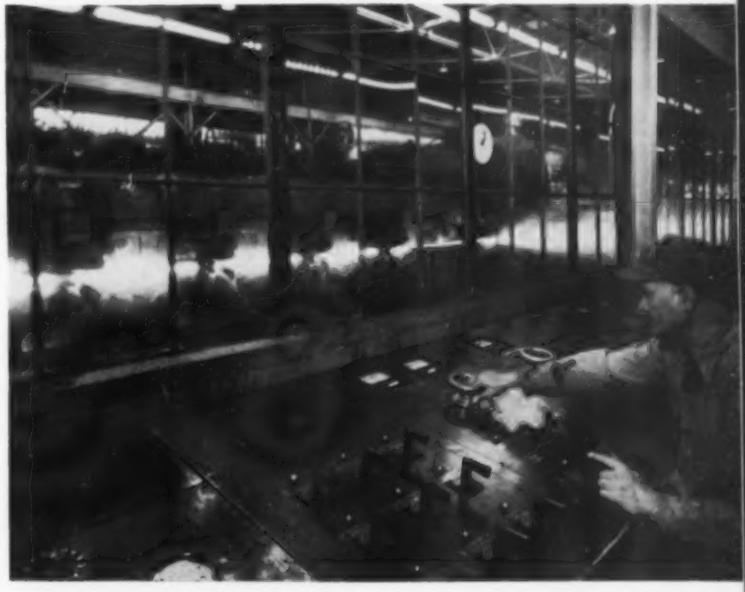
Disconnecting clutches are provided for the eccentrics so, if it is desired, the smaller diameter pipe can be cut without deflecting; that is, by raising and lowering saw blade with upper eccentrics into path of pipe travel. This would be desirable if the saw is to be used for cutting cold pipe.

Also, if desired, the upper eccentrics can be disconnected and the smaller diameter pipe then will be lifted by lower cutting cam and eccentric only, the same as described under first saw having a cutting range ⅜ to 2-in.

For other applications, two simplified saws, working on the same basic principle, have been developed:

1. A saw for making only one length of cut with

Figure 3 — Saw may be seen in operation at right center of illustration.



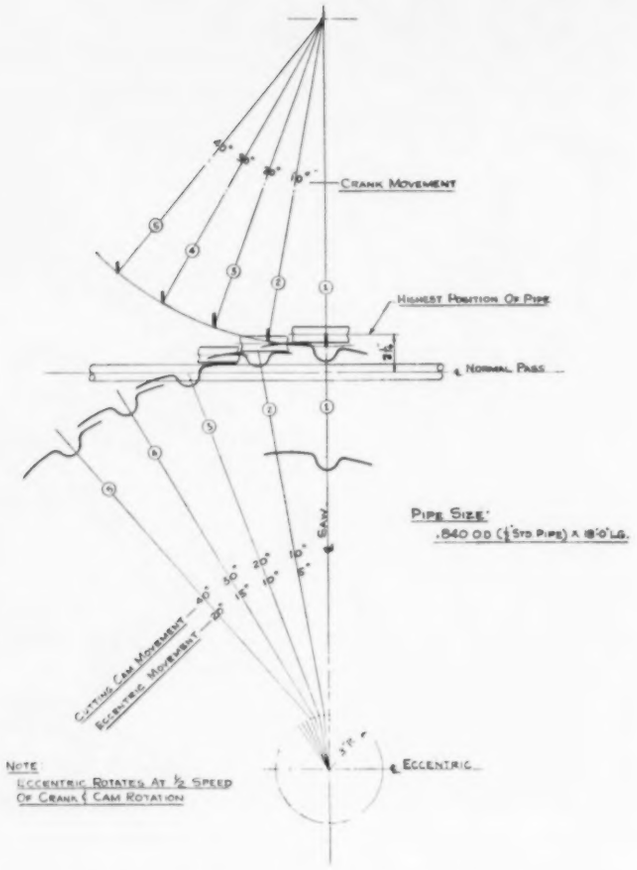


Figure 4 — Sketch shows cut diagram for 1½-in. diameter pipe.

minor adjustment for length correction only. See Figure 7. This saw has a fixed crank radius corresponding to length of cut to be made. All adjustments have been eliminated except position of lower rotating cutting cam which can be adjusted to take care of various diameter saw blades.

2. A saw with a small adjustment for cutting length, single lengths 18 to 22-ft, double lengths 36 to 44-ft.

Capacity of these saws, depending on mill layout, are for ⅛ to 2-in. pipe size or ⅜ to 4-in. pipe size. If desired, and a demand should develop, the cutting length range of these saws can be extended for lengths of 100-ft or more.

In order to maintain synchronization of mill and saw, three methods have been employed:

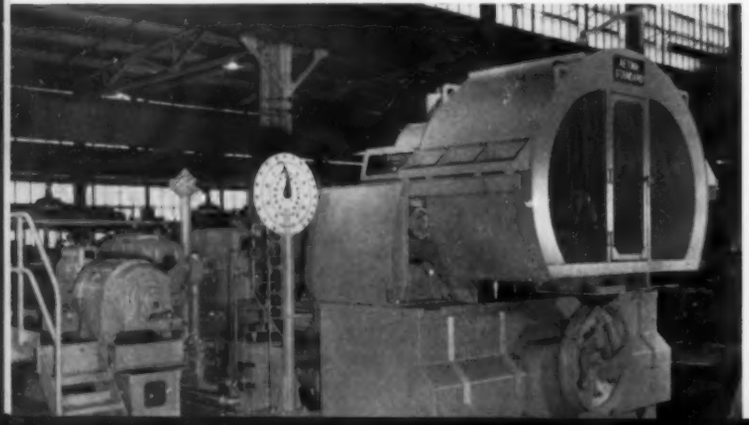


Figure 5 — This new saw can cut pipe up to 4 in. in diameter.

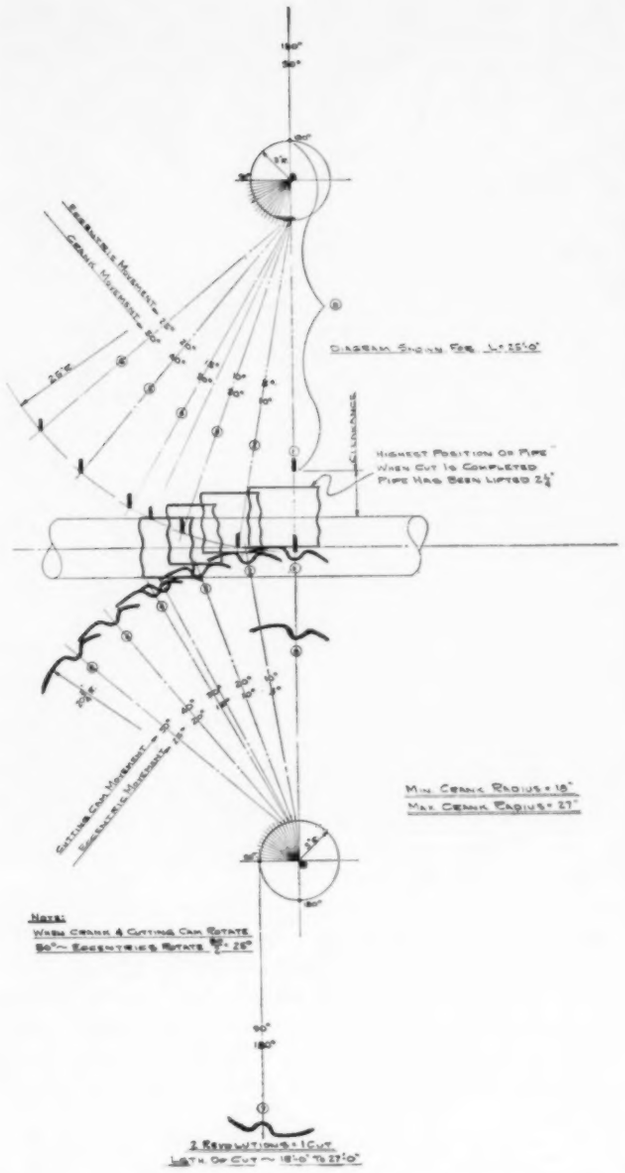
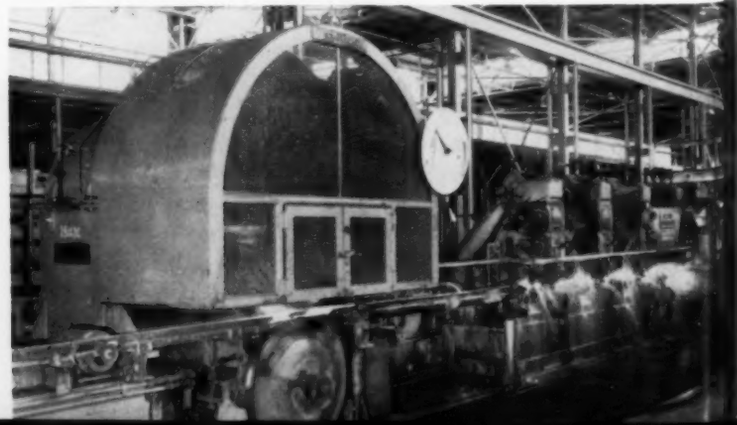


DIAGRAM SHOWN FOR L = 25'0"
CLEARANCE
HIGHEST POSITION OF PIPE WHEN CUT IS COMPLETED PIPE HAS BEEN LIFTED 2½"
MIN. CRANK RADIUS = 18"
MAX. CRANK RADIUS = 27"
NOTE:
WHEN CRANK & CUTTING CAM ROTATE 90° — ECCENTRIC IS ROTATED ½ = 25°
2 REVOLUTIONS = 1 CUT
LGTH. OF CUT — 18'0" TO 27'0"

Figure 6 — Sketch shows cutting diagram of saw shown in Figure 5.

1. Electrical synchronization. Saw is driven by a separate motor. Mill motor and saw driving motor are synchronized by syncro-tie control to keep saw in step with mill speed. With this connection, required cutting tolerances of plus or minus 1-in. are obtained.
2. Forming, welding, and reducing mill and saw are

Figure 7 — This relatively simple saw was designed to make one length of cut only.



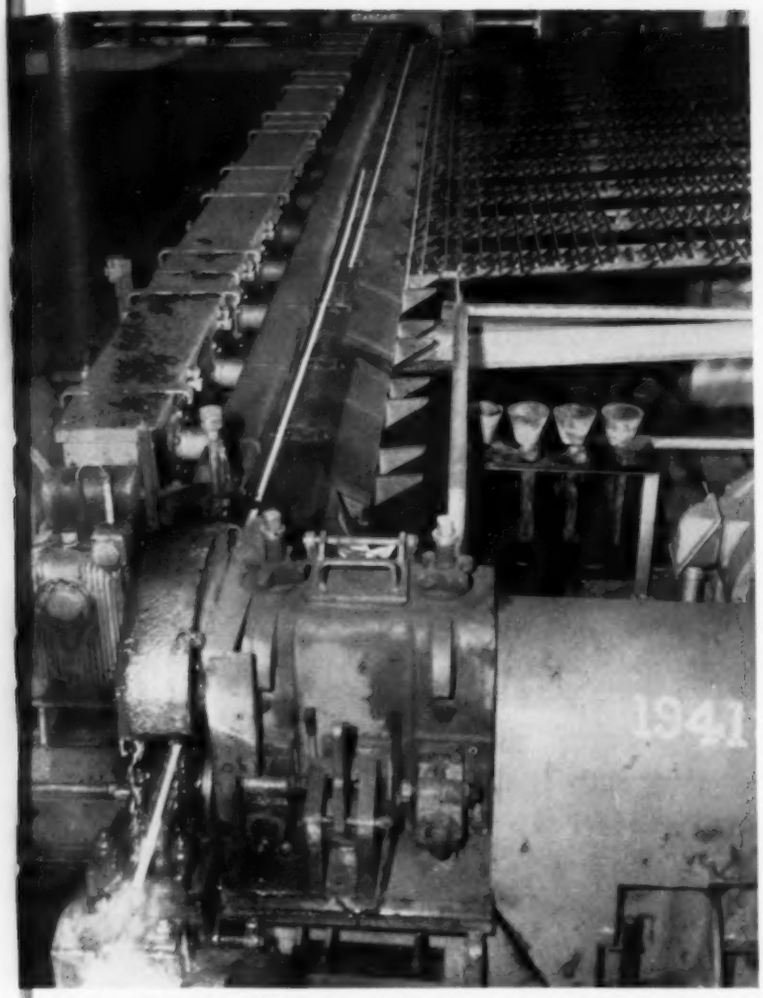


Figure 8 — With this kick-off it is possible to stagger the pipe on the runout conveyor.

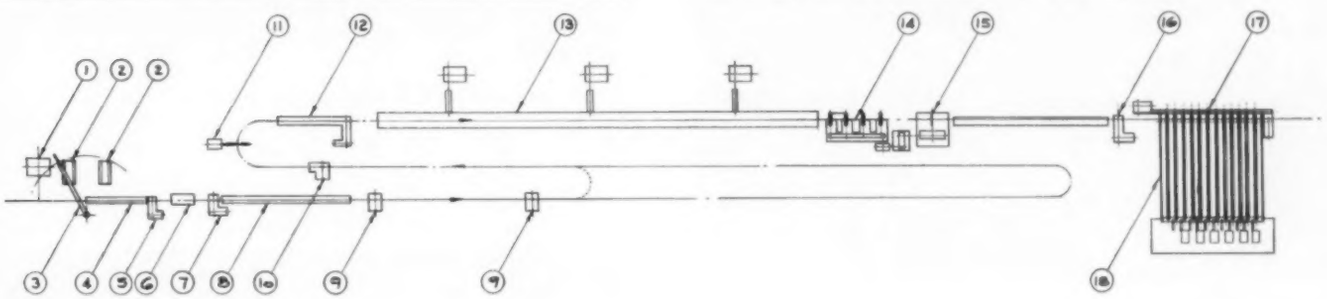
3. The forming, welding, and reducing mill have individual motor drives; the last stand or two stands of mill are mechanically connected to saw drive. Some of these mills are under construction at the present time.

Several mills which were built in 1940 for a maximum pipe speed of 400 fpm have been modernized by the installation of a new rotary saw and are operating now with maximum speeds up to 800 fpm.

In order to obtain the required increase in heating capacity of furnace, skelp width has been increased by adding additional reducing stands to mill, also increasing reduction per stand.

With the increased pipe speed, the handling of pipe after cutting became more important—in particular, a foolproof method had to be found to transfer pipe from runout conveyor onto cooling bed. Figure 8 shows a new rotating screw type kickout in operation. This kickout makes it possible to stagger the pipe on the runout conveyor and have the cut lengths skid and come to a complete rest in a second trough in kickout section before being transferred onto cooling bed. With this kickout, only a small amount of separation is required between successive cut lengths coming from saw. The speed of runout conveyor needs to be only slightly higher than delivery speed of mill.

The kickout screw always makes one complete revolution for one pipe transfer initiated by a flag switch. During this cycle, while one pipe is moved sideways from centerline runout into skidding position, the pipe which previously had come to rest in skidding trough is deposited on cooling bed. The pipe coming from mill is moving into transfer position behind pipe in skidding trough. With this type of kickout, 50 pipes per minute can safely be transferred onto cooling bed.



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	PLATFORM SCALE FOR COILS	10	PINCH ROLL NO 2
2	STORAGE RACKS	11	LOOP CONTROL
3	JIB CRANE	12	FURNACE THREADER
4	UNCOILER	13	SKELP HEATING FURNACE
5	LEVELLER	14	FORMING & WELDING MILL
6	SKELP WELDER	15	FLYING HOT SAW
7	PINCH ROLL NO 1	16	SIZING MILL
8	SKELP SUPPORT	17	KICKOUT
9	MAGNET ROLLS	18	COOLING BED

Figure 9 — This continuous butt weld pipe mill produces ⅛ to ¾-in. pipe.

driven by one motor. A drive located between mill and saw permits adjustment of saw speed to take care of variation of mill delivery speed caused by different roll diameter and pipe size. By experience, it has been found that with this mechanical connection cutting tolerances can be obtained of plus or minus ½-in. With a steady mill speed, the cutting tolerances are still closer.

A new small modern continuous butt weld pipe mill is shown in Figure 9. This mill has a capacity of ⅛ to ¾-in. Maximum speed is 850 fpm.

Table I shows a chart giving relation between pipe size, skelp size, and mill production.

Figures 10 and 11 show this mill in operation.

The mill has a reported yield from skelp size to pipe shipped of 96 to 97 per cent.

TABLE I

Pipe size, in.	Pipe wall thickness, in.	Skelp size and thickness, in.	Total number of stands forming, welding and reducing	Maximum mill speed, fpm	Maximum tons per hr
⅛	0.068	1 15/16 x 0.065	8	840	6.2
¼	0.088	2 9/16 x 0.085	8	775	9.9
⅜	0.091	3 3/16 x 0.088	8	715	12.2
½	0.109	3 13/16 x 0.105	8	540	13.8
¾	0.113	4 5/8 x 0.109	8	510	15.3

A layout of a new continuous weld mill, capacity ½ to 2-in., is shown in Figure 12. Maximum speed of mill is 1100 fpm. Table II shows pipe size, skelp size, and mill production.

A typical layout of continuous weld mill just recently completed in Germany is shown on Figure 13. Table III shows pipe size, skelp size, and production of this mill.

Figure 14 and Table IV show layout of continuous weld mill, skelp size and production for two mills just recently completed for this country.

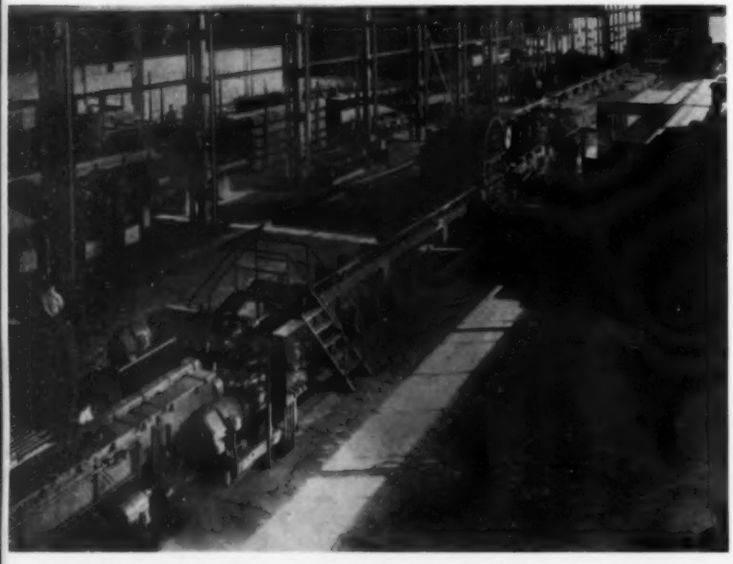


Figure 10 — The mill in Figure 9 is shown in operation in this view.

As will be noted from Figure 14, additional reducing stands have been provided in order to standardize on skelp sizes for various pipe sizes. Different wall thicknesses are obtained by more or less stretch reducing in reducing mill. The economy of skelp standardization and stretch reducing depends on production requirements, scheduling of sizes, scheduling of skelp mill, supply of skelp size. These factors vary greatly in different mills and have to be analyzed in order to justify the additional equipment required. With stretch reducing, wall reductions of approximately 30 per cent have been made when producing ⅜ and ½-in. pipe from 2⅜-in. outside diameter. The pipe reduced had been electric resistance welded and reheated for reducing.

On continuous weld mills, to this date, no wall reductions have been made.

As mentioned before, the continuous weld mills, shown in Figures 13 and 14 are provided with additional reducing mills and stretch reducing can be applied if desired. The mills have just been completed and no actual operating data is available at this time.

INDUCTION WELD PIPE MILLS

The induction weld pipe mill, like the continuous weld mill (Fretz-Moon type), uses a hot rolled skelp or a hot rolled slit strip and converts it into standard pipe.

In the following will be given a short summary of mills in operation and future trends:

Induction weld pipe mills are in operation in Europe for the production of standard pipe sizes ⅜ to 6-in.

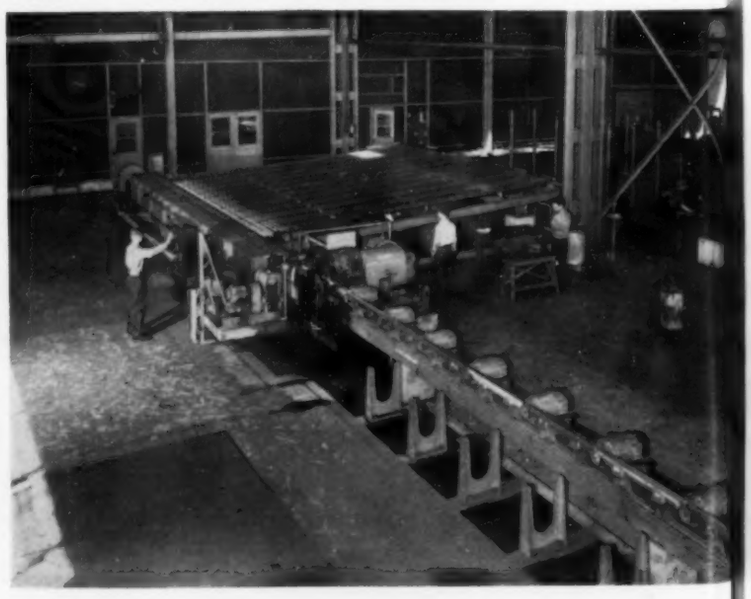
Range of mills:

½ to 1-in.
1¼ to 2-in.
2½ to 4-in.
} Maximum speed of these mills 50 fpm, transformer capacity, 200 kva, 4000 cycle.

2½ to 6-in. { Maximum speed of this mill 100 fpm, transformer capacity, 400 kva, 4000 cycle.

The pipe is formed cold, either by the conventional

Figure 11 — Top speed of this mill is 850 fpm.



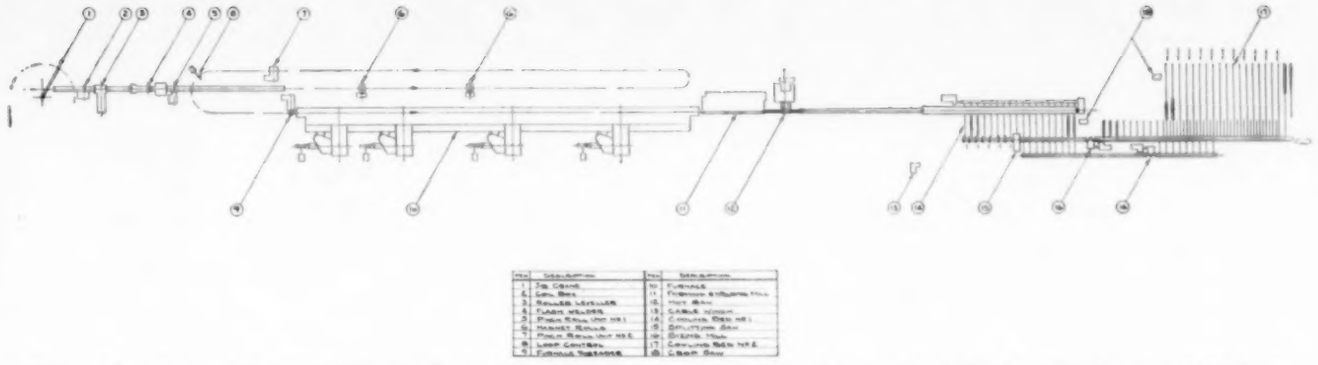


Figure 12 — Layout shows mill recently built to produce pipe from ⅛ to 2-in. in diameter in speeds up to 1100 fpm.

TABLE II

Pipe size, in.	Pipe wall thickness, in.	Skelp size and thickness, in.	Total number of stands forming, welding and reducing	Maximum mill speed, fpm	Maximum tons per hr	8-Hr record tons per hr	Average monthly production
½	0.109	5 x 0.109	12	1050	26.7	23.8	25 ton per hr — based on scheduled time, including roll changes and delays of all kinds.
¾	0.113	5 13/16 x 0.113	12	900	30.5	28.7	
1	0.133	6¾ x 0.133	12	750	37.8	32.2	
1¼	0.140	7 13/16 x 0.140	12	600	41.0	36.8	
1½	0.145	8 5/16 x 0.154	12	500	40.7	37.9	

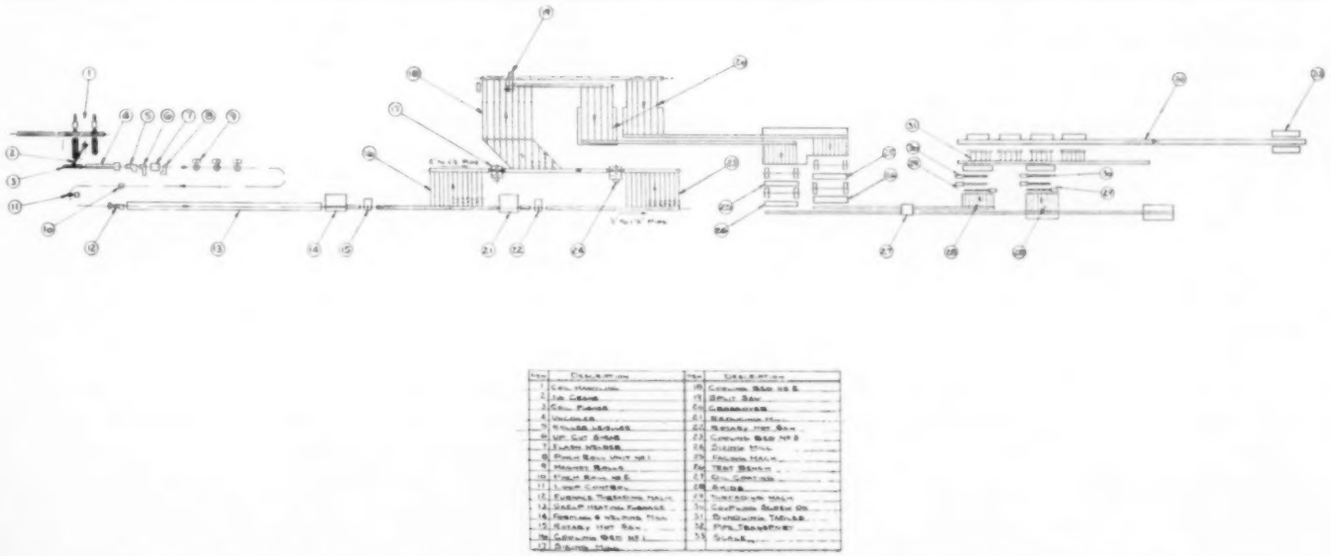
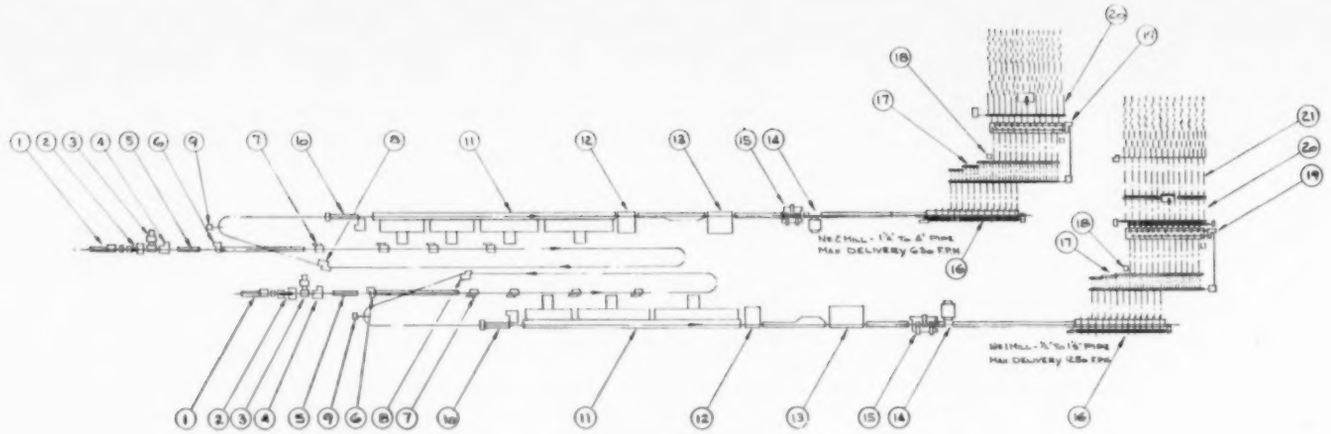


Figure 13 — Layout shows a new, continuous, butt weld pipe mill built in Germany to produce ½ to 2½-in. pipe.

TABLE III

Pipe size, in.	Pipe wall thickness, in.	Skelp size and thickness, in.	Total number of stands forming, welding and reducing	Maximum mill speed, fpm	Maximum tons per hr
½	0.109	11.1 x 0.147	10 + 20	990	25.2
¾	0.113	11.1 x 0.147	10 + 17	990	33.5
1	0.133	11.1 x 0.147	10 + 13	770	38.5
1¼	0.140	11.1 x 0.147	10 + 9	570	38.8
1½	0.145	11.1 x 0.147	10 + 7	445	36.2
2	0.154	11.1 x 0.147	10	360	39.2



Item	Description	Item	Description
1	Coil Pusher	12	Forming & Welding Mills
2	Uncoiler	13	Reducing Mill
3	Leveler	14	Hot Saw
4	Shear	15	Sizing Mill
5	Welder	16	Screw Type Kickout
6	Pinch Roll No 1	17	Hot Straight & Cool Bed
7	Magnet Roll	18	Cropping Saw
8	Pinch Roll No 2	19	Water Boom
9	Loop Control	20	Screw Transf. & Split Saw
10	Furnace Threader	21	Chain Transfer
11	Furnace		

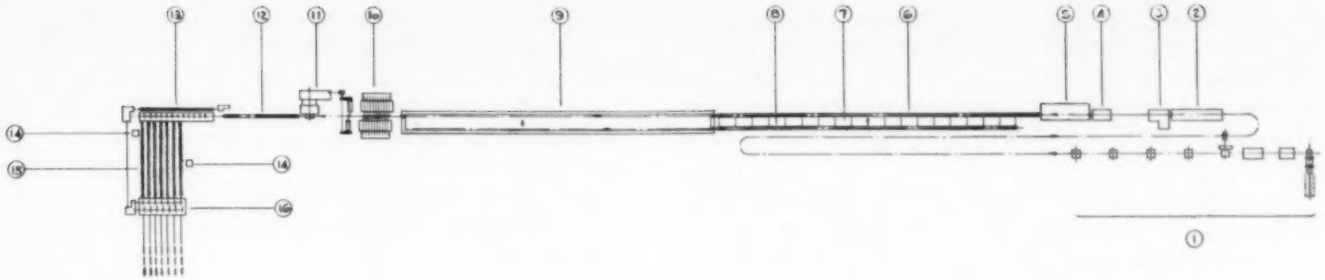
Figure 14 — Layout shows two new continuous weld pipe mills recently completed in the United States. One mill produces pipe from 1 to 1½ in., and the other from 1¼ to 4 in.

TABLE IV

Pipe size, in.	Pipe wall thickness, in.	Skelp size and thickness, in.	Total number of stands forming, welding and reducing	Maximum mill speed, fpm	Maximum tons per hr
Mill No. 1					
½	0.109	8 x 0.109	16	1100	28
¾	0.113	10 x 0.113	16	975	33
1	0.133	12 x 0.133	16	735	37
1¼	0.140	16 x 0.140	16	630	43
1½	0.145	16 x 0.145	14	525	43
Mill No. 2					
1½	0.145	16 x 0.145	14	610	50
2	0.154	16 x 0.154	14	450	50
2½	0.203	16 x 0.203	12	290	51
3	0.216	16 x 0.216	10	225	52
3½	0.226	16 x 0.226	8	190	52
4	0.237	16 x 0.237	6	160	52

roll forming, or by a combination roll forming and pulling skelp through a rotating bell. In this process the seam is located on top of pipe so that drippings and scale will not fall onto induction coil. As will be noted, the capacity of induction weld mills in operation is very small compared to continuous weld mills. The mills are attractive to some companies especially in countries where a high production continuous weld mill, on account of the small production requirements, cannot be justified; also in localities where fuel is expensive, but electric power is readily available.

In contrast to continuous weld pipe, a heavy flash occurs at the seam—both on the outside and inside of pipe. The outside flash is removed by a cutting tool, the same as is being done by resistance weld mills. On smaller pipe diameter, it is not possible to remove the inside flash. On larger diameter pipe, the inside flash can be removed with a cutting tool. The inside flash also has been rolled down by using two outside rollers backed up by two small rollers inside of the pipe. On account of the cold forming, the pipe produced is work hardened. Depending on applications, the pipe after



Item	Description	Item	Description
1	Uncoil & End & End Welder	9	Pipe Reheating Furnace
2	Forming Mill	10	Reducing Mill
3	Welder	11	Flying Saw
4	Sizing & Straighting Mill	12	Saw Mill Run-Out Conv.
5	Flying Cut-Off Machine	13	Screw Type Kickout
6	Weld & Mill Run-Out Conv.	14	Crop Saw
7	Transfer Conveyor	15	Cooling Bed
8	Furnace Run-In Convey	16	Water Boosh Tank

Figure 15 — Layout shows a proposal which combines an induction weld pipe mill with a reheat furnace, stretch reducing mill, and high speed flying saw.

TABLE V

Pipe leaving induction weld mill		Pipe leaving stretch reduction mill	
Size	Fpm	Size	Fpm
2	170	1½	800
2		1¾	625
2		1	400
2		1¼	325
2		1½	260
2			
2½	130	...	...
3	130	...	...
3½	110	...	...
4	100		

welding is to be stress relieved or annealed.

The layout of an induction weld mill is similar to a continuous weld mill consisting of: conventional uncoiling end, pipe forming equipment, induction coil, welding rolls, sizing rolls, cut-off and side transfer.

In order to increase production, higher speed mills are under construction both here and in Europe. The newer mills will have speeds of 150 to 175 fpm based on skelp 0.110 in. thick. To further increase the production in the smaller pipe sizes, it has been thought to combine the induction weld mill with a pipe re-heat furnace, stretch reducing mill and high speed flying saw.

Figure 15 shows possible layout of such a combination mill. Table V shows possible production capacity.

Compared to a (Fretz-Moon type) pipe mill of equal capacity, such a layout would have the following disadvantages:

1. More equipment is required.
2. More floor space is required.
3. Higher installation costs.
4. Reduction in yield if pipe is cut in lengths before reheating and subsequent stretch reducing due to heavy wall crop ends.
5. If pipe is not cut after welding, special synchronizing control is required to synchronize induction weld mill and stretch reducing mill.
6. Additional operator is required for induction weld mill.
7. Difficulties producing extra heavy and double extra heavy pipe.
8. Necessity of removing inside and outside flash.

To compensate for these disadvantages, it is claimed that the induction weld mill will adopt itself better for the use of slit strip. On account of cold forming and high welding pressure, possible laminations in the steel which are opened up by the slitting operation will not be as detrimental as they would be in the Fretz-Moon process.

On the other hand, it should be mentioned here that slit strip has been used successfully on Fretz-Moon Mills for production of standard wall pipe without sacrificing quality or yield. This, of course, requires a steel free of laminations.

DISCUSSION

PRESENTED BY

H. N. LANG, Superintendent Tube Mill, Wheeling Steel Corp., Benwood, W. Va.

A. J. DOYLE, Superintendent Continuous Weld Pipe Mill, Kaiser Steel Corp., Fontana, Calif.

WILLIAM RODDER, Vice President-Engineering, Aetna-Standard Engineering Co., Pittsburgh, Pa.

N. C. RUBIN, Vice President-Director of Sales, The Yoder Co., Cleveland, Ohio.

A. L. THURMAN, Executive Vice President, Mannesmann-Meer Engineering and Construction Co., Easton, Pa.

H. N. Lang: Papers on the subject of welded pipe, and particularly those prepared and presented by Mr. Rodder on continuous weld mills, are always welcomed and avidly studied by the small, but ever grow-

ing fraternity of engineers, operators, and executives who live and work with these mills every day. I should be surprised if Mr. Rodder's paper is not critically studied and given serious thought by pipe mill executives who must compete with continuous mills' product, as well.

At Benwood, West Va., Wheeling Steel has two continuous weld mills, side by side, installed about ten years apart. One of the developments discussed by Mr. Rodder was incorporated in the newer mill. We have the rotating hot saw, but missed out on the screw type kick-out which complements the flying saw. As was stated, the mechanical and electrical maintenance on our hot saw has been insignificant. The major source of delay from the saw has been caused by inaccuracies in speed adjustment between pipe and crank arm, permitting the saw blade to carry the leading end of the pipe which has just been sawed up into the saw cage. This sometimes causes burning of lead-in wires or damage to motor or saw blade.

The percentage of delays attributed to the saw from all causes—operating, mechanical, electrical—by years, since installation is as follows:

Year	Per cent of operating time
1949	2.63
1950	1.36
1951	0.79
1952	0.85
1953	0.81

I am going to mention a feature which might not come to the attention of engineers unless volunteered by one of us who supervise the operation of the products of their skill. Despite great progress, steel mills and pipe mills are not yet automatic. (We have installed a control instrument which we dubbed "automatic pilot" on our No. 2 Mill. Skilled and alert men are still the controlling factor in high production of quality pipe. A prime objective of every mill supervisor is to instill in these men the will, the desire, the compulsion to do their best. They must want to do their jobs better than anyone in the business before the full capacity of the machines, furnaces, and all facilities can be realized. To the degree that engineers give weight to the convenience, welfare, and peace of mind of the workman, they contribute to the operating success of their own designs.

A. J. Doyle: Mr. Rodder's new designs and developments by his company in the manufacture of continuous weld pipe have been progressing so rapidly that we operators have a hard time keeping up with them. He and his company should be commended on the progress they have made in the new designs and latest developments for the manufacturing of continuous weld pipe.

However, with the installation of Mr. Rodder's new type hot saw, it does not just require the installation of the saw, it also requires the installation of high speed conveyors to remove the pipe from the production line and avoid jam-up or cobbles.

I would like to ask Mr. Rodder from an operating stand point, on new mill installations with stretch reducing, what consideration has been given to the end weld, that is where the two ends of strip are jointed together. In the forming and weld mill, the temperature of the skelp is brought up to 2500 F at the edges for welding purposes and 2250 to 2300 F in the cross section of the strip for forming. What happens to the end weld in the stretch reducing mill? What stress is placed on the end welded portion during this operation? What has been done to avoid pulling end welded section apart?

In the heating of continuous weld pipe skelp, to start off, you get a two to three per cent loss of yield due to scale and cinder, you do have cobbles, you do have to needle the furnace, you do have rejections, you do have recuts, and so I would like to know how the 97 per cent yield from skelp to finished pipe figures are arrived at.

William Rodder: Referring to the last question, the yield of 96 to 97 per cent reported was based on a small mill, capacity $\frac{1}{8}$ to $\frac{3}{4}$-in. (See Figures 7, 8, 9, and Table I.) The mill layout compared to other mills is quite simple. The yield reported from actual figures covering period of one year was 96.1 per cent.

Referring to stretch reducing in connection with continuous weld pipe mills, I am afraid the end welds will present a real problem. As mentioned before, up to this date, stretch reducing has not been applied in continuous butt weld pipe mills. The standard practice is to maintain wall in the forming, welding and reducing mill—or in most instances, the skelp is actually rolled a few thousandths thinner than the finished pipe wall. In some instances, where the wall thickness was reduced slightly, difficulties were encountered with breaking of end weld.

The two mills shown on Figures 13 and 14 are arranged for possible stretch reducing. The stretch reducing will be applied in a second mill located in line with forming and welding mill. The stretch reducing will be applied at a reduced temperature. In addition, guides are provided between successive roll stands and in case pipe breakage occurs, it will not cause any cobble and stoppage of mill.

N. C. Rubin: I would like to add a few words about the development that has been experienced in the last two or three years on induction weld mills.

We have been working at this thing for quite some time and have worked with various frequencies, ranging between 3,000 to 10,000 cycles, and while we do not find a tremendous difference between those frequencies, we have more or less rested on 10,000 cycles for certain reasons, mostly economic, and because of the type of equipment that is available for power supply.

While these figures that Mr. Rodder gave us on production of induction weld pipe are true as far as we know, I think it is noteworthy to say that our developments in this country have shown better speed and quality than the advancement in the induction weld in Europe. It is also true that there are some four or five mills in operation in various parts of Europe, mostly in Germany, making induction weld pipe. Their speeds are limited. I think the speeds that Mr. Rodder mentioned of 50 to 120 fpm are those that you will find in Europe, but, a new mill that has been recently shipped from our plant into Italy will actually produce

U. S. Standard 2-in. pipe at a speed of about 180 fpm, and ½ and ¾-in. pipe at 250 or 260 fpm. Also, as mentioned here, the use of the stretch reducing mill will quite likely be in effect in most of these induction weld mills. By that, it would mean that while the welder will produce the pipe at speeds ranging between 160 to 260 fpm, the ultimate speeds will run between 500 and 800 fpm. Finally, it seems to be rather apparent that the ultimate use of these stretch reducing mills in combination with induction weld mills will produce pipe of ½ to 2 or even 3-in. in tonnages approaching 60 and 70,000 tons per year, depending upon the amount of hours of operation.

In this country, there has been a small induction weld mill in operation for a little over two years now, producing EMT conduit. It is a 300-kva unit and is operating very succesfully. It is producing ½ and ¾-in. EMT conduit at speeds over 200 fpm and the largest size up to 2-in. at 150 fpm.

All in all, the induction weld mill with a reducing mill probably will not attain the speeds of Fretz-Moon mills, but we do think that in areas where there are tonnage requirements of 20 or 30,000 up to 60 and 70,000 tons per year, that there is a place for induction welding. You will undoubtedly see much more of this development in the next few years, although there will probably be more of these installations in foreign countries than here in United States.

A. L. Thurman: When we talk of an increase of from 500 to above 1000 fpm in a span of a very few years, we have seen progress and I know that Mr. Rodder has had quite a heavy hand in making this increase possible.

In presenting his paper Mr. Rodder has also talked about the induction welding mill. Different frequencies have been used and as we all know the depth of penetration of the induction welding depends upon the frequency, the higher the frequency the less the penetration. As the frequency is increased, however, the welding effect is also increased both due to the higher heat concentration and the greater welding effect of the higher frequency. It is therefore obvious the induction welding mill has its best performance when it is designed to produce thin-walled tubing. With heavier walls, the heat penetration requires lower frequencies and a very much lower operating speed will result. Extreme flexibility for an induction welding mill would require the use of a variable frequency alternator for power supply to the inductors, but it is doubtful if such an expense could be justified, at least not at this stage of the development. Perhaps further developments in electronics will broaden the application of this type of mill.

At this stage, the induction welding mill is fairly new, and novel, and it is perhaps being applied where the novelty may help to sell this type of mill. It has its field, it is true, but the tendency with a new tool is to stretch its application beyond the point of full usefulness. Actually an electric resistance weld mill in combination with suitable other components will cover a very broad field of requirements; Mr. Rodder has compared the high speed continuous butt weld mill to the induction welding mill, whereas a more realistic comparison could be made with the straight resistance weld mill. A properly designed resistance weld mill can produce the same product as the continuous butt weld mill, whereas we generally would think of an induction welding mill as being used more for special materials and special applications. A good share of the first cost of the induction welding mill is the high frequency conversion equipment, and the resistance weld mill is generally of much lower cost.

As concrete examples of the applicability and diversity of the resistance weld mills, there are two mills already in operation, one at Hahnsche Werke near Dussburg, Germany, the other at our Rath Werke of Deutsche Mannesmann Rohren Werke near Dusseldorf, Germany, where the operation is practically identical to that outlined in the paper for the induction welding mill. These welding mills produce pipe principally in sizes around 3-in. where the inside flash can be removed without difficulty. It is welded in 100-ft lengths, transferred over to a heating and annealing furnace, heated and then put through a stretch reducing mill, hot saw, and then finished pretty much as indicated in the paper. The mill at the Rath Werke has a unique stretch reducing mill which has three rolls per stand and it has produced and cut to length ⅜-in. tubing at speeds above 1000 fpm. This type of a mill layout should make a much more favorable comparison with the continuous butt weld mill than would a similar induction weld mill layout.

In the selection of any of these mills, it must be considered that each has its own field, and in the application of any mill one must analyze the conditions at hand and select the proper mill based upon first cost, production requirements, material, fuel cost and availability. In other words, the use of good application engineering principles will result in the selection of the proper mill to give you the best mill for the money you have available and to meet the production requirements of the equipment.

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"TRANSFORMER MATERIALS"

By D. C. GRAHAM and L. R. BRONLUND

Power Transformer Engineering

General Electric Co.

Pittsfield, Mass.

▲ A transformer basically is a simple and extremely efficient device. It consists of two or more coils that provide a path for the electric current, solid and liquid insulation to confine it to that path, electrical sheet steel to provide the necessary magnetic field for voltage generation and transformation, and finally, a steel container to house and protect the weather-sensitive structure and to provide a means for dissipating the heat generated. However, increasing demands for electric power have increased the complexity of transformers and their size, while shipping clearances remain unchanged. Figures 1 and 2 show a typical large unit shipped in a one-piece tank. Improvements in electrical and structural steel are contributing to the successful fulfillment of these demands on the electrical industry.

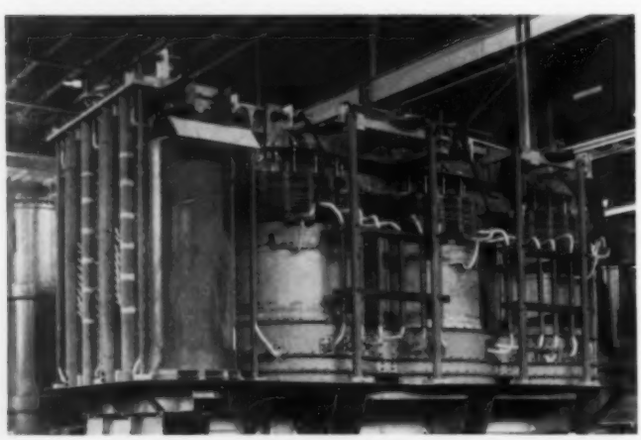


Figure 1 — Large transformers such as this are shipped in a one-piece tank.

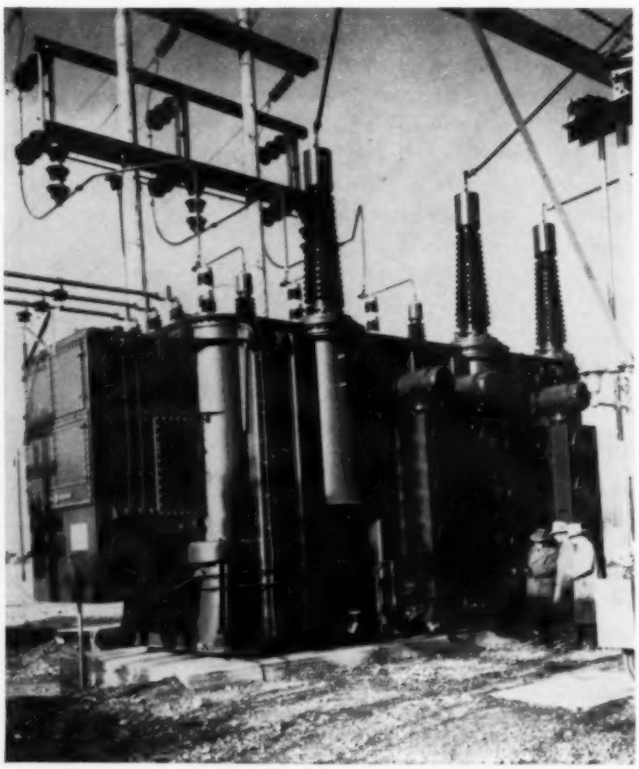


Figure 2 — Developments in core steels have kept down the size of transformer units.

CORE STEEL

Of all the transformer components, core steel is the least replaceable and contributes the most to the reduction of size, weight, and cost, and to improvement in efficiency. It is through the use of highly-directional, low-loss core steel with greatly improved permeability and by improved transformer design that the size of units which can be built today has increased to 350,000 kva. The transformer plant of our company uses more

than 20 per cent of the available oriented silicon steel. As one of the major users, it assumes the responsibility for major improvements. Extensive research programs are carried on at the mill, in the research laboratory, and in the transformer factory, to further improve the magnetic characteristics of oriented silicon steel as well as develop new and improved materials. In line with this policy, several million dollars have been earmarked for a new metals research laboratory, which is scheduled for completion in 1955. This laboratory will contain pilot facilities such as arc furnace, cold rolling mill, and other pieces of equipment for the experimental processing of metallurgical materials. Through this laboratory a rapid transition of new developments from the research laboratory to commercial production can be achieved.

Because of the critical nature of oriented silicon steel, careful quality-control checks are made on this material through all the various stages of processing. During the melting of the steel, the chemical compositions are adjusted to meet rigid requirements. Carbon is reduced

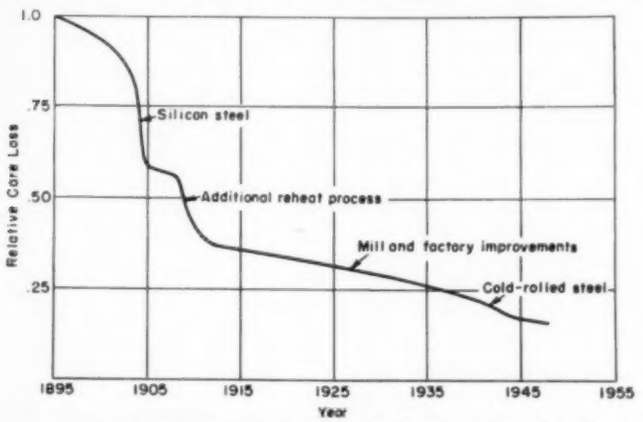


Figure 3 — Core losses have been reduced very appreciably as shown in this curve.

to a minimum, while silicon, manganese, and sulphur are controlled to strict specifications. After the steel is rolled to gage and normalized, further checks are made on the chemical composition and magnetic characteristics such as loss, per cent orientation, and permeability. After the final anneal at the factory, special testing equipment has been set up to make quality-control checks on the magnetic characteristics of the lamination before assembly into the core, as well as tests on insulation and mechanical deformation. It is through research and adequate controls of the basic material and processing that the quality of power transformers has been maintained in the past and will improve in the future.

Considerable progress over the years in the improvement of core steel is shown in Figure 3. One of the major early improvements was the addition of silicon to common iron. The silicon had three important functions which:

1. Caused deoxidizing reaction in the molten steel which reduced the hysteresis loss.
2. Increased the electrical resistance of the material which decreased the eddy losses.
3. Practically eliminated the serious effects of aging present with common iron.

Through research and continuing development, improvements were made in hot-rolled steel by increasing the silicon content and improving heat treatment and processing at the mill and the transformer factory. The higher silicon content decreases the loss but also increases the transformer exciting current.

In 1933 attempts were made to produce silicon steel in a continuous coil by using the Steckel reversing cold mill. The limitations of the mill and the work hardening of the material made heat treatment between the passes necessary to reduce the material to the desired gage. This series of cold rolling and heat treating resulted in oriented strip steel with lower losses and higher permeability.

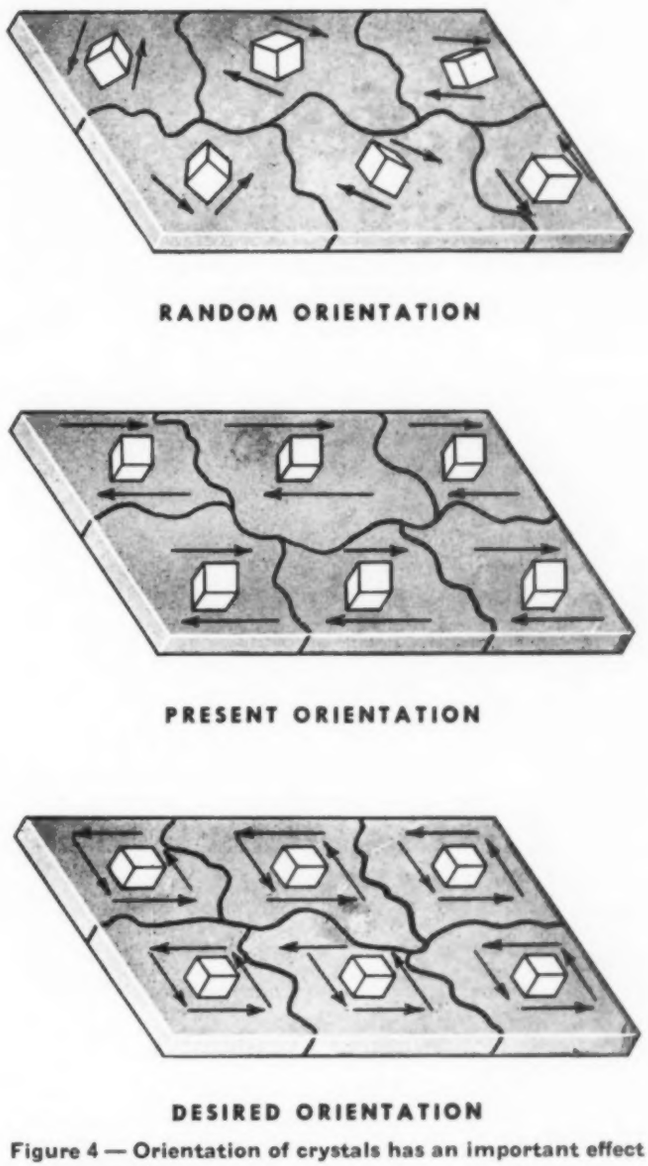


Figure 4 — Orientation of crystals has an important effect on core loss.

The chart (Figure 3) does not fully show the real benefits of this new oriented steel. In order to make a direct comparison between hot-rolled and cold-rolled steel, it is necessary to use a common flux density. Because of the improvement in permeability and loss, the cold-rolled oriented steel can operate at densities 10 to 20 per cent higher than hot-rolled steel and with equal or lower losses and exciting currents.

It is interesting to explore briefly why oriented steel is better than hot-rolled steel and what are the plans

Figure 5 — Core is cradled in a clamping structure to minimize the strains on the steel.

for the future material. Figure 4 shows the metallurgist's concept of cubes of steel in the hot rolled or random oriented steel, the present oriented steel, and the desirable future four-fold oriented steel. Tests on samples of present oriented steel cut at various angles to the rolling direction show that the excitation required to produce a given density with the grain or rolling direction is only one-tenth of that for 45 degree and one-fifth the amount required for 90 degrees to the rolling direction. In terms of the diagram, the cube edge represents the with-grain path, the face diagonal, the 90 degree path, and the cube diagonal, the 45 degree path. Since hot-rolled steel consists of cubes with their edges at various angles to the flow of flux, it is easy to see why it has poor permeability. Transformers built with non-oriented steel therefore, have exciting currents that are many times that of present transformers built with cold-rolled oriented steel, which has between 80 and 90 per cent of the cube edges lined up with the rolling direction.

The cube face of present oriented steel is at approximately 45 degrees to the steel surface. As long as magnetic flux flows with the grain, this orientation is perfectly satisfactory. In large power transformers it is necessary for the flux to flow at angles varying from 0 to 90 degrees to the rolling direction in the corner regions. For these core constructions, it is desirable to have the cube face parallel with the steel surface. This will give two equally easy directions of flux flow 0 and 90 degrees. The general shape of the curve for loss vs angle to rolling direction would be similar to that for excitation vs angle to rolling direction. The advantage is one in which minimum stored energy results in minimum loss. The core design is then automatically adjusted to minimum loss in the corner regions.

Oriented strip steel has many advantages in loss and permeability, but has the disadvantage of being sensitive to strain. Tension applied in the direction of the grain slightly reduces the loss, while face and axial compression greatly increase the loss. Likewise, various degrees of bending involving both compression and tension will have an adverse effect on the loss and exciting current. For example, a flat piece of steel tested in a flat strain-free condition and again in a strained condition with a bend equal to an eight-foot radius will show a 30 per cent increase in the loss and 225 per cent increase in reluctance. From basic information such as this, various mechanical deformations have been evaluated in terms of loss in the finished transformer. It is, therefore, extremely important that the steel industry exercise accurate control of gage, burr, surface, and steel flatness. The electric industry has a counterpart to maintain that quality during the processing and annealing. These are difficult problems and require special attention to mechanical handling and thermal gradients.

In processing the steel at the mill, there are a number of thermal and mechanical problems involved. After the material has been rolled to gage and the carbon

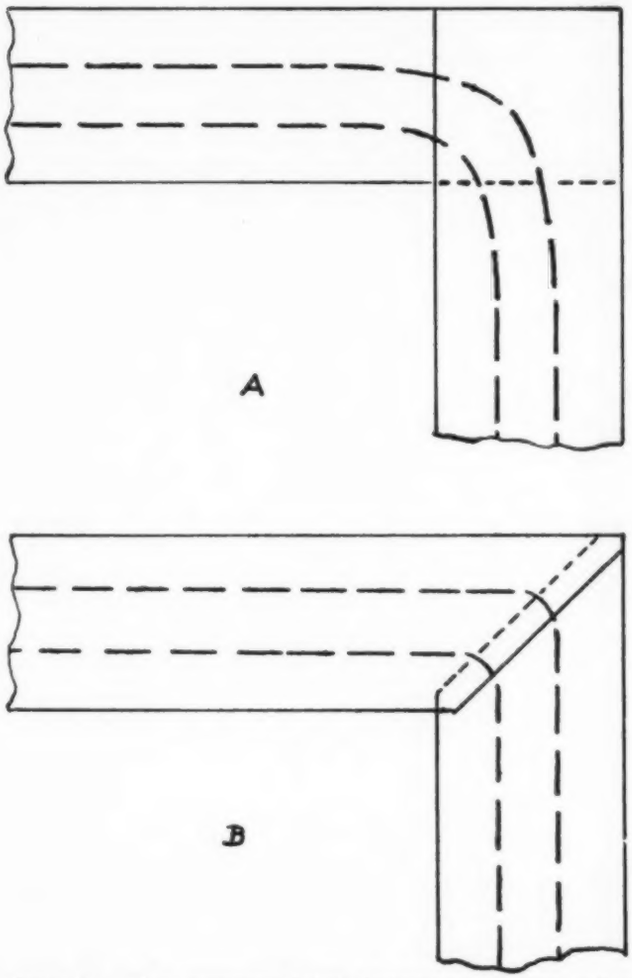


Figure 6 — Two common joint designs are in use today with oriented steels.

removed, it is heated in the coil form to temperatures approaching the melting point. At this temperature, the final crystalline structure is developed and the material cooled to room temperature. Because of the wide widths of steel involved, there may be large thermal gradients across the sheet width. These thermal gradients produce high stress in the material which causes flow at these high temperatures. It is, therefore, necessary to exercise proper control on the rates of heating and cooling to limit the mechanical damage to the material. The steel is then passed through a heat flattening line under tension which removes the coil set produced during the annealing cycle and a limited amount of other thermal and mechanical distortions. With the steel under tension during the heating and cooling cycle in this line, it is important to maintain low thermal gradients across the sheet. Diameters of

the bridle reel for applying tension, and take-up reels must be designed to prevent creep in the steel at the operating temperatures. If either stress or temperature or both are too high, the material will receive a minor coil set. This coil set interferes with the processing of the steel at the transformer factory and must be removed during the final annealing operation or it will cause increased core loss in the finished transformer.

During the heat flattening process, high temperature insulating materials such as magnesium phosphate and other commercially available materials can be applied. Large catenaries provide ample time for the coating to set up before passing over the rolls. As a result, very thin and uniform coatings can be applied. These coatings result in improved space factor in the finished transformer core.

The heat flattening process is a difficult one, and can best be accomplished with wide widths of steel. Since transformers use relatively narrow widths of steel for their punchings, it is necessary to slit the steel to the required sizes. Since slitting is a potential source of mechanical damage, it can undo all of the diligent efforts to produce flat steel during the heat flattening line. Therefore, careful attention must be paid to the design and setup of the machine, and the take up reel to prevent mechanical damage to the soft material. Many of the transformer factories have their own slitting equipment so that they can accurately control this operation, and achieve greater flexibility in their inventory.

The directional and strain characteristics of oriented steel dictate the core design and clamping structure. Early in the art of applying strip steel, wound type cores were used with and without joints. At present, a precut, preformed core is used in single phase power transformers which is shown in Figure 5 ready to receive the coils and insulation. This core is annealed in its final form and cradled in a clamping structure to minimize strain on the steel. This core construction is being extended to larger sizes to obtain full advantage of the highly oriented steel produced today.

Figure 7 — A special clamping plate is used with large cores.

The application of this steel to large single and three-phase plate cores is more complicated and involves some form of joint structure between the legs and yokes. There are two common joint structures in use today with oriented steel. One is the butt and lapped joint as shown in Figure 6-A which is a carry-over from cores using random oriented steel. With present oriented steel the butt lapped joint has some useful applications but in general the mitre joint gives lower core loss. The mitre joint as shown in Figure 6-B consists of sheets of steel butted and lapped along a 45 degree cut much like a picture frame. There are many variations but they all provide a path so that the flux flows more nearly with the grain. This joint structure also gives a magnetic circuit which is easier to excite. This easily excited core requires a greater uniformity of magnetic characteristics in the basic material, as well as material assembled into the core. Since small amounts of strain make large variations in the steel's characteristics they can practically nullify the advantage of the joint structure.

CORE AND COIL CLAMPING STRUCTURE

Since the core is the electrical and mechanical foundation of a transformer, it is essential that the separate sheets of silicon steel of which it is composed be held tightly in place. It is equally necessary to provide adequate means of absorbing and transmitting to the core, the forces exerted by the coils during the short circuit periods. There are also forces involved in crane lifting the complete internal assembly of the transformer. Finally, provision must be made for supporting cables, leads, and various auxiliary devices. All these design requirements are met by steel members called "clamps" located on either side of the top and bottom core yokes. The yokes and clamps are pulled together until tight. For small transformers, these clamps are made from structural steel angles and channels, such as the commercial structural steel used in building industry. For medium and large transformers, the channel or angle shapes are obtained by welded assemblies. Heavy studs made from material similar to SAE-1035 steel, clamp the core together. Heavy electrical insulation is molded around the studs where they pass through the core. Small transformers have yoke bolts on each end of the clamps outside the core, and steel tie rods between top and bottom clamps to take care of the axial short circuit and lifting forces. Large cores use a specially designed clamping plate next to the core, as shown in Figure 7, instead of external tie rods.

TANK FOR HOUSING CORE AND COILS

The protective container or tank shown in Figure 8 is made entirely of steel. Since the core and coils produce heat, most transformers must have provision for a liquid insulating and cooling medium — usually mineral oil around the core and coils to remove the heat. The tank also serves as a container for the oil.

Because of the damaging effect of moisture on trans-

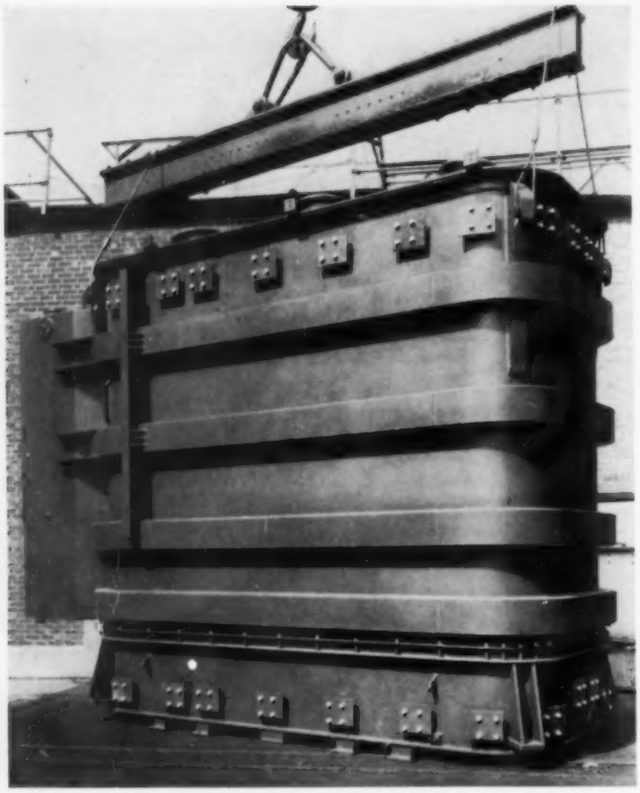
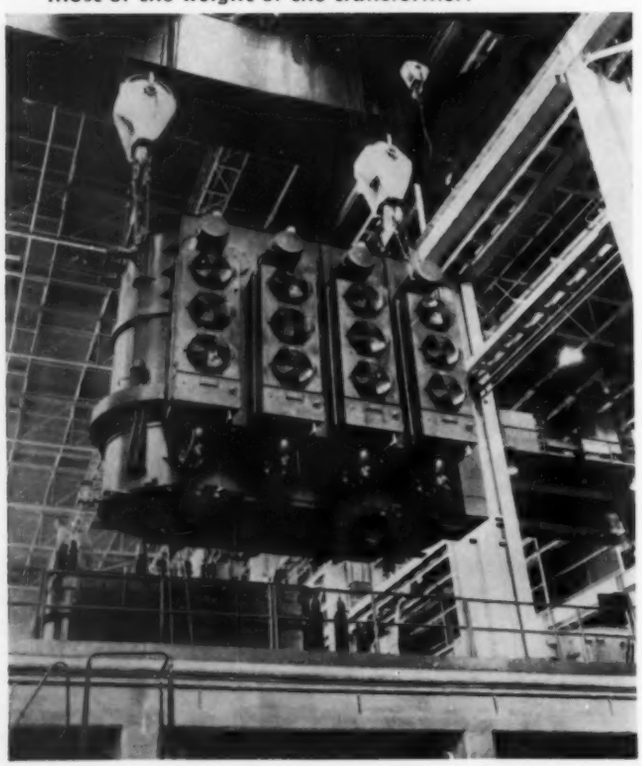


Figure 8 — Protective tank is normally made entirely of steel.

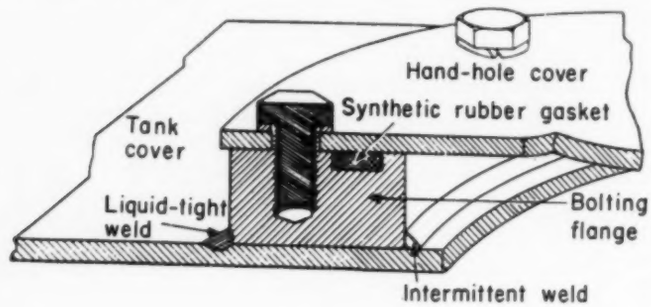
formers, most tanks must be hermetically sealed from the outside air. It must, therefore, be *bottle tight.* In addition, it must withstand up to 7½ psi operating pressure because of expansion of oil due to temperature changes. Some transformers require dry de-aerated oil, and filling under full vacuum, so that the tank has to be designed for 15 psi external pressure as well. In other words, a transformer tank must be designed to "take it." Not only must it withstand the specified pressures during normal operation and under vacuum filling, but it must also be strong enough to carry the weight of oil and core and coil assembly when the transformer is lifted or jacked, as shown in Figure 9.

Figure 9 — Tanks must have sufficient strength to carry most of the weight of the transformer.



The shape of a transformer tank may be round, oval, elliptical or rectangular — whichever will best accommodate the core and coils and make possible minimum weight and dimensions.

The tank shell is made from steel plates ranging from ¼ to ½ inch in thickness. To withstand the internal or external pressures, the shell is adequately reinforced by horizontal bands. The bands consist mostly of inverted steel channels, which form box



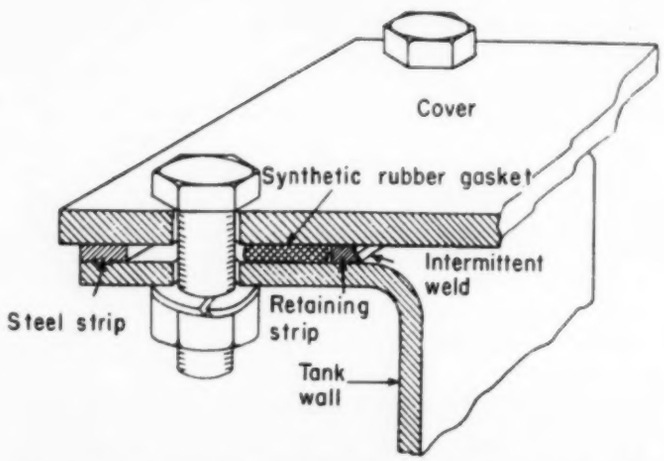


Figure 10 — For tight construction, tank covers are bolted to wide flanges and sealed by gaskets.

girders when welded to the tank shell. Reduced height and a clean appearance are thereby obtained. These factors are important when shipping dimensions and floor space are considered.

To assure permanent tight construction, the tank covers are bolted to wide flanges and effectively sealed by gaskets tightly compressed by uniformly spaced bolts, as shown in Figure 10. Bolts never pass through the cover to the inside of the tank. The cover may also be welded to the tank if desired. The welded cover joint is made in such a manner that it can easily be removed by chipping or gas burning when disassembly of the transformer is necessary.

All joints such as those made between cover and bushings, manholes, etc., are made with gaskets compressed by closely spaced bolts. These joints are readily made in the field.

The cover is made from flat steel plate, slightly

domed to shed water. All gaskets are made of liquid-proof and heat resistant synthetic rubber. The gaskets are set in grooves, or are held in position by retainers so arranged that all parts are bolted metal to metal, thus placing gaskets under the correct pressure to assure oil-tightness.

Tanks with a welded inspection joint near the bottom are furnished on large transformers when customer's lifting facilities are not sufficient to lift the core and coil assembly out of the tank. This joint, like the welded

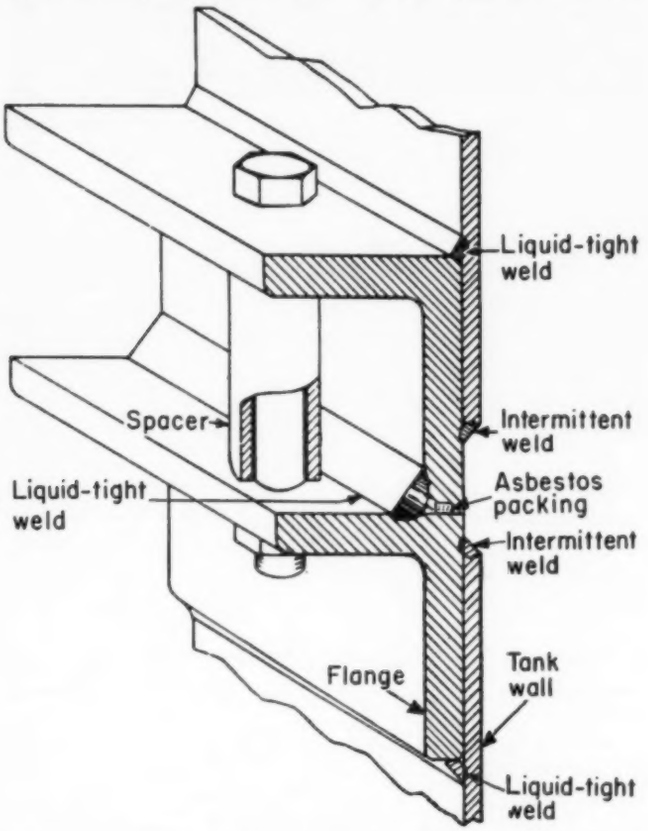


Figure 11 — An inspection joint may be used on some transformers which can be removed easily for field disassembly.

cover joint, is made for easy removal by gas burning or chipping when disassembly of the tank in the field is necessary. Figure 11 shows the construction details.

Several ways of cooling the oil have been developed. Most common are steel cooling tubes welded to steel headers which in turn are welded or bolted to the tank, shown in Figure 12. Both ends of the tubes are swaged in order to thicken the wall and diminish the end diameter to improve welding conditions.

HANDLING TRANSFORMERS

The transformer base is suitable for moving the unit into position by skids, truck wheels, or both. The tank base must, therefore, be of strong construction with structural reinforcements. On large transformers weighing more than 35 tons, inverted channels are welded to the base plate for reinforcement and support, while on smaller units, "I-beams" are used.

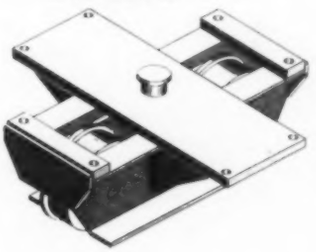
Trucks for transformers that weigh 35 tons or less are an integral part of the tank base. On transformers weighing over 35 tons, the trucks consist of individual bolted-on wheel units. These units may have one or

Figure 12 — The use of cooling tubes is one way to keep oil temperatures down.

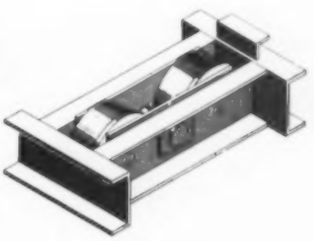
two wheels. The direction of motion may be either crosswise or lengthwise of the tank. Bi-directional trucks are provided when motion in both directions is desired. In the center of the bi-directional truck unit is a pivot point for changing the direction of motion. (See Figure 13.)

Four types of wheels are furnished: standard flanged, double flanged, broad flanged, and unflanged. Standard

Figure 13 — Several designs for transformer trucks are shown here.



Two-wheel, bi-directional equalizer unit, for transformers weighing more than 80 tons



Two-wheel equalizer unit, one direction. For transformers larger than 80 tons

One-wheel, bi-directional unit, for transformers weighing between 35 and 80 tons

Wheel and axle unit typical of types used on transformers 35 tons and smaller. Some units are integral with tank base

flanged wheels are designed for rails only; broad and double flanged wheels are designed for rails and hard surfaces; unflanged wheels, for rolling on hard surfaces. Wheels for transformers weighing 15 tons or less are made of grey cast iron similar to ASTM-A-48. Those for transformers weighing more than 15 tons are machined from a solid bank, gas burned from steel plate, similar to ASTM-A-212 Grade B.

Four lifting lugs are welded to the transformer tank for lifting the complete transformer. Below 18,000 pounds (per lug) capacity, mild carbon steel forgings having a minimum tensile strength of 55,000 psi are used. Over 18,000 pounds (per lug) capacity, lugs are gas-cut from solid steel plate rounded by machining to prevent abrasion where lifting sling bears on the hook. The material for these lugs is similar to ASTM-A-201 Grade A.

Four jack bosses are also welded to the tank for jacking the complete transformer. These bosses have a bracket shape fabricated from steel plates welded together.

FABRICATION

Power transformer tanks are made from high-grade open-hearth steel plate of commercial quality with sheared edge and a specified chemical base. The chemical per cent composition is as follows:

Carbon	0.15 max
Manganese	0.30 to 0.60
Phosphorous	0.04 max
Sulphur	0.05 max
Silicon	0.15-0.30

A certificate of ladle analysis made by the manufacturer is required. A check analysis may be made by the purchaser from a sample representing each melt. The chemical composition thus determined must conform to the requirements of the specification within the AISI standard permissible variations for check analysis.

All seams, flanges, lifting and jacking lugs, braces and other parts attached to the tank are welded; nothing is riveted. Tank assembly involves several types of welding. However, the majority of welds are made by the "metallic shielded arc" method, as shown in Figure 14. All welds which must be liquid tight are made from the outside where they are accessible for testing and repair. These welds are tested with hot oil under pressure for several hours.

The major difficulty in steel fabrication has been the shortage of steel since the early part of the war. This situation involves frequent inability to obtain material as specified and makes it necessary to accept other material which requires quick improvisation in design. When structural shapes are unobtainable, they must be fabricated from plate stock at an increase in cost. Another kind of difficulty occurs when steel laminates. This condition is apt to occur when cover flanges are made from burned-out rings. Because such lamination is not generally detected until the oil test reveals it after the flange has been welded to the cover, much of the time and labor spent on the part is lost. Material substitution is always costly and delaying. However, in spite of these various difficulties, the quality of transformers has been maintained.

Figure 14 — A great deal of welding is involved in the manufacture of transformers.

Every year the transformer manufacturing industries use between 200,000 and 300,000 tons of steel because it is a widely available, low-cost structural material, which can be readily fabricated by any of a number of well known methods. The ease with which any desired shape may be obtained by gas cutting, forming, and welding is a major factor favoring the exclusive application of steel to the welded portions of transformer construction. It is no wonder that steel comprises 75 per cent or more of the total weight of a transformer excluding the cooling liquid. From this brief description, it is evident that steel plays a major role in the transformer industry.

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"THE APPLICATION OF TRANSFORMERS IN THE STEEL INDUSTRY"

By L. G. LEVOY

Application Engineer

Industrial Engineering Section

General Electric Co.

Schenectady, N. Y.

▲ THE transformer as we know it today is a simple, convenient, and reliable device which permits a-c circuits of different voltages to be coupled together, thereby making it possible for the generators, transmission lines, secondary distribution system, and a great variety of loads to be operated at their most suitable voltage.

The manufacture of steel in the U. S. A. reached an annual production of approximately 112,000,000 tons in 1953. Since, on the average, each ton of steel requires about 225 kwhr of electric energy to produce it, the

annual consumption of electricity by the steel mills in the U. S. A. is about 25 x 10^9 kwhr. Part of this energy is generated by the steel plants and some of this power is utilized at the generator voltage. However, much of the power comes into the plants through transformers and some of it passes through additional transformers inside the plants.

The transformers used in the steel industry range in size from small transformers used in control and instrumentation to large power transformers rated 70,000 kva or more. In addition to power transformers, the steel industry uses lighting transformers, rectifier transformers, arc furnace transformers and many other specialized types of transformers. All of these transformers have interesting design and application features. However, this paper will deal primarily with the application of power transformers because this subject is of more interest to the majority of persons in this audience.

Power transformers used in the steel industry are very similar to those used in the utility field or in industry generally. From the steel producer's viewpoint, the transformer is one of the vital links in his power supply system. He wants to place the transformer in some out-of-the-way location, and have it sit there quietly with 100 per cent availability, delivering power efficiently at the proper voltage and without any attention. He places a very high value on reliability.

The modern power transformer is one of the best qualified pieces of electrical apparatus to meet these requirements. Its efficiency ranges from 99 to 99.5 per cent. It is a static device and requires little attention. Records indicate that with proper application and a modest amount of attention, the failure rate has been reduced to less than one in 2500 transformer years.

Since the transformer is one of the vital links in the power transmission and distribution system, it should always be selected to fit into the system to best advantage. In other words, a transformer should be selected as a coordinated part of the entire system, rather than as a separate unit. Thus, the proper application of power transformers becomes part of a system coordination study, and the study of transformer application becomes, in part, a study of the systems in which they are used.

TRANSFORMER STANDARDIZATION

While it is possible to build a transformer to meet practically any requirements, it is a mutual benefit to the customer and manufacturer if the transformer specifications are drawn up to cover standard designs and standard optional features. Since standard-rated transformers and the optional features available with the standard ratings provide a wide variety of choice, it is possible to meet the majority of the requirements with standard equipment at lower cost to the user. Special transformers are used only in those systems where the standard transformers do not satisfy the requirements.

For example, the standard three-phase, 60-cycle voltages are given in Table I. Note the relation between the nominal system voltages, the transformer rated voltages, and the utilization voltages.

TABLE I

Nominal system voltage	Generator rated voltage	Transformer secondary rated voltage	Transformer primary rated voltage	Three-phase motor and control rated voltage
120	120	120	120	110
240	240	240	240	220
480	480	480	480	440
600	600	600	600	550
2400	2400	2400	2400	2300
4160	4160	4160	4160	4000
4800	4800	4800	4800	4600
6900	6900	6900	6900	6600
11500	11500	12000	12000	11000
12000	12500	12000	12000	11000
13200	13800	13200	13200	13200
13800	13800	13800	13800	13200
22900	.....	.....	22900	.....
34400	.....	.....	34400	.....
43800	.....	.....	43800	.....
67000	.....	.....	67000	.....
110000	.....	.....	110000	.....

Since transformers are normally furnished with four 2½ per cent taps, two above and two below rated voltage, the standard voltages listed in the foregoing table meet most of the requirements.

In general, the user should provide a functional specification of what the transformer is to do including kva rating, voltages, taps, and impedance requirements, and then let the manufacturer build the best transformer to meet these requirements. The American Standards Association has prepared a standard C-57.12a which lists standard ratings, voltages, taps, impedances, etc., and in addition, covers standard mechanical features and optional features. Acceptance of these standard accessories with standard locations makes it unnecessary for the user to specify such details as the location of the bushings or drain valves, etc. These standards reflect present optimum arrangement and unless something special is required, it need not be mentioned.

THREE-PHASE VERSUS SINGLE-PHASE TRANSFORMERS

Most modern power systems use three-phase transformers. Single-phase transformers were more popular in past years because it was considered that one spare single-phase transformer could replace any unit in a bank made up of three single-phase units. Furthermore, the transformer could be operated in open delta at part load if one transformer was defective and no spare was available. Also, shipping and handling limitations sometimes dictated the use of single-phase transformers.

Due to major improvements in design, modern transformers give greatly improved reliability. The application of forced air cooling, development of improved insulations, and improved core steels have reduced the volume and weight as compared with their predecessors so that most applications now favor the use of three-phase transformers. Three-phase transformers occupy substantially less space than three single-phase transformers, and are less expensive to install since there are fewer connections and foundations. In addition, three-phase power transformers have a lower first cost and lower losses when compared with three single-phase

units. Where service reliability requires spare capacity, two half-size three-phase transformers can be used instead of one three-phase unit.

TRANSFORMER COOLING

In the early days, most transformers were self-cooled. Today, there are five principal methods of cooling available for power transformers. The most commonly used cooling methods on transformers in industrial plants are either self-cooled or self-cooled/forced air-cooled. Table II gives the increase in rating available with forced air cooling.

TABLE II

Transformer size in kva	Increase in capacity for one-stage fans, per cent	Increase in capacity for two stages of fans, per cent
501—2499	15	..
2500—11999	25	..
12000—150000	33	67

In the smaller sizes, transformers are nearly always self-cooled since there is less to be gained by forced air cooling, and the requirement for auxiliary power and control is an added deterrent to the use of forced cooling. In the larger sizes, the forced air cooling is becoming more popular. They are particularly applicable where short peaks or emergency overload requirements indicate larger ratings than are needed continuously. The fan cooling provides a relatively inexpensive way of handling such loads compared with the price of a self-cooled transformer of the higher rating. The fan-cooled rating provides increased power without increasing the interrupting duty on the associated switchgear. The proper way to select a large power transformer is to evaluate the losses first on the expected duty cycle, then select the transformer. For high continuous loadings, the self-cooled unit having a higher efficiency may be a better investment in spite of its higher first cost.

Water-cooled transformers are applicable where space limitations require the smallest possible unit or where operation in high ambient is required.

Forced-oil / air-cooled and forced-oil / water-cooled transformers are also available. These forms of cooling are used primarily in large utility transformers.

TRANSFORMER INSULATION

There are three general types of power transformers available:

1. Oil-filled.
2. Askarel-filled.
3. Dry-type (sealed or ventilated).

Large high voltage (above 15 kv) power transformers are almost universally oil-filled. Oil is an excellent insulating and cooling medium for a transformer. These transformers are generally located outdoors because oil is inflammable and, therefore, represents a fire hazard, especially indoors. Lower voltage transformers for use outdoors are usually oil-filled also.

For transformers 13.8 kv and below, which may be located indoors or outdoors close to a building, a non-inflammable insulating liquid (askarel) is usually preferred to minimize the fire hazard, and still provide the same high insulation level and freedom from maintenance that the oil-filled transformer provides.

The open dry-type transformer is also suitable for indoor use and has the advantage of lighter weight. With both the open and sealed-type dry transformers, liquid is eliminated. The dry-type transformer has the disadvantage that it has a lower BIL (Basic Impulse Insulation Level) and, therefore, should not be applied on circuits subject to severe transient overvoltage from lightning exposure on associated circuits. Likewise, it should not be applied in a location where smoke and dust are very severe as accumulations may block the cooling passages or require frequent cleaning.

APPLICATIONS TO EXISTING SYSTEMS

Since the transformer must always fit into the system, in many cases the primary voltage, secondary voltage, and winding connections are already established by the existing system. Rating is established by the job the transformer is called upon to do. Here the application engineer has very little leeway except to select the impedance to make sure that it will parallel properly if parallel operation is required, and to make sure that it will be satisfactory from the standpoint of fault level on the existing equipment with which it will be operated. He should also check the voltage regulation and tap range to make certain that the transformer will give the desired performance. Voltage ratings of transformer windings are always specified at no load and this must be taken into consideration in calculating the voltage under various load conditions.

APPLICATIONS TO NEW SYSTEMS

To illustrate factors other than the requirements of an existing system, which influence the selection of power transformers, consider the application of power transformers to a new system of the type shown in Figure 1. The actual plant will have many more feeders and some sub-distribution buses, but the typical circuits shown will serve for illustrative purposes.

Assume that the utility service is available at 34.4 kv, but that the voltage varies from 31.8 to 37 kv at this point in the system. The fault level on the utility circuit is 1500 mva and the utility circuit is solidly grounded at the sending end. An analysis of the plant operations indicates that the plant will need to be able to purchase a maximum of 20,000 kva although normally it will need to purchase only about 12,000 kva. The plant plans to operate two 18,750-kva turbine generators on low Btu content fuel available from the process.

This plant contains 30,000 hp of synchronous motors ranging in size from 1000 to 12,500 hp. In addition, there are 15,000 hp of induction motors ranging in size from 1 to 5000 hp, 12,000 kw of rectifiers, 10,000 kva of annealing furnace transformers, and 5000 kva of lighting and other miscellaneous load.

The plant is spread out over an area ½ mile wide, and 1½ miles long. The layout is such that it will be necessary to locate the power house at one end of the property.

The primary voltage of the 15,000/20,000-kva transformer is established at 34.4 kv by the utility supply. To permit satisfactory division of kvar between the two systems, and at the same time hold the plant bus voltage substantially constant, it will be desirable to specify load ratio control of ±10 per cent in addition to the standard ±2½ and ±5 per cent straddling taps.

Each bus section of the local plant should be grounded to provide for grounding in event of isolation from the rest of the system. Therefore, the transformer will be specified 34.4 kv delta on the high voltage side, and wye-connected with the neutral brought out for grounding on the low voltage side.

The secondary voltage for this transformer must now be selected. From the range of motor sizes involved, it appears that three levels of voltage will be required in the plant. Thus 13.8 kv is ideal for the main buses, 2400 volts for the intermediate level and 480 volts for the low power level. The suggested power transformer voltages for the various loads are as follows:

13.8 kv—All motors 2000 hp and above, rectifiers and annealing transformers.

2.4 kv—Motors from about 300 to 2000 hp.

480 v—Motors from 1 to 300 hp.

This classification is to be used only as a rough guide and exceptions will be made when economically justified by particular circumstances. The economic comparison should take into account the cost of the switchgear, transformer, motor control, cable, and motor. It will be influenced by the location in the plant and the voltage available for serving other motors in the nearby area.

For this case, 13.8 kv was selected rather than 6900 volts because standard 500 mva metalclad switchgear provides more leeway in momentary current rating which is desirable when induction motors are present on the system. Thus, at 6900 volts, momentary current may be the limiting item whereas at 13.8 kv, the full interrupting rating of the circuit breakers can normally be utilized. In addition, the transmission of relatively large blocks of power over the distances involved will require less copper at 13.8 kv and the voltage regulation will be improved. All rectifiers, transformers, and large motors will be served at 13.8 kv wherever feasible to avoid double transformation.

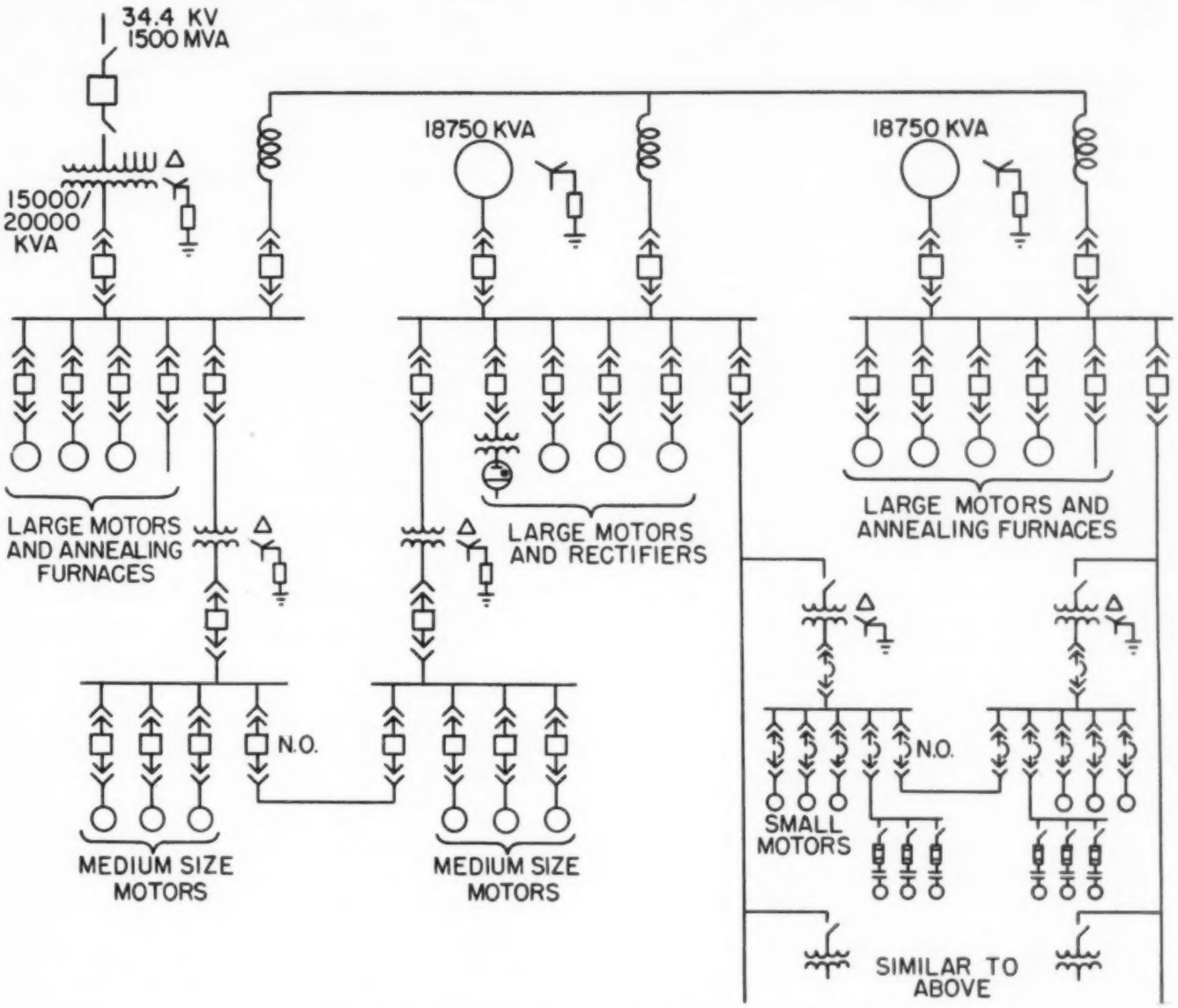


Figure 1 — Sketch shows application of power transformers to a new system.

The 2400-volt level is selected for the intermediate size motors because power will not have to be transmitted very far in this case, and it is a suitable and economic voltage for them. The same is true of the 480-volt motors.

Now all power transformer voltage levels have been established for this plant. Standard taps $\pm 2\frac{1}{2}$ per cent and ± 5 per cent should be provided on all transformers to provide for voltage adjustment at various locations in the system. All transformers should be connected delta-wye with the neutral brought out for grounding as shown in Figure 1.

Grounding the system neutral at each voltage level minimizes the magnitude and severity of transient overvoltages from lightning, switching, ground faults, or other causes. It also makes possible fast relaying to remove the faulty circuit promptly, thereby minimizing damage at the point of fault.

To establish the proper impedance of the 15,000/20,000 kva power transformer, it is necessary to consider the fault levels and switch-gear rating in the proposed system. Since it is planned to use 500 mva interrupting capacity switchgear, each bus section will be limited to this level. The synchronizing bus reactors will be designed to transmit all necessary power to any bus in event of failure of the power source to that bus. Since the bus sections have about equal load capacity, flexibility and symmetry can be obtained if the fault contribution from the transformer to its bus is about equal to the fault contribution of the generators to each of their buses. Since generators of this class normally have a subtransient reactance of about 0.1 per unit on their own base, they can contribute approximately ten times their rating to a bus fault or 187,500 kva. The 34.4 kv system impedance expressed on a 15,000 kva base (self-cooled rating of the transformer) is 0.01 per unit.

Since the normal impedance for a transformer of this rating and voltage classification is 7 per cent, the transformer can contribute $\frac{15{,}000}{0.01+0.07} = 187{,}500$ kva to a fault on its bus. Consequently, we can conclude that 7 per cent impedance is satisfactory for this transformer.

The maximum size of 2400-volt transformer units will be limited to about 7500 kva to permit application of 150 mva standard metalclad switchgear. For economy reasons, the maximum size of 480-volt transformers will be limited to about 1500 kva. Using these maximum sizes, the transformers for each of these voltage levels can use standard impedance for their respective size and voltage classification without getting into uneconomical switchgear ratings. Substantial savings in installed cost can be realized on the 2400 and 480-volt circuits by installing the transformers as close to their load centers as possible, to decrease the amount of secondary cable required. This also provides for better voltage regulation and lower copper losses. This plant will require a total of about 60,000 kva of transformers of various ratings.

The 15,000/20,000 kva-power transformer will be located outdoors and will be oil-filled type OA/FA (self-cooled/forced air-cooled) and will be supplied with high creepage bushings on both high and low voltage windings as it is located in an area where there is a considerable amount of dust and smoke. This extra creepage will minimize the frequency of cleaning required on the bushings. This transformer can be specified as part of a primary unit substation to obtain a completely coordinated design. All of the other transformers are to be located indoors as part of a metalclad lineup including both transformer and switchgear and, therefore, will be askarel-filled, as exposure to lightning surges and dirty atmospheric conditions exist. These transformers can be specified as a part of a secondary unit substation providing a coordinated design from the incoming lines to the outgoing feeders. This greatly simplifies the specification and ordering of the equipment.

Suitable air break disconnecting switches will be supplied on the primary of the 13.8 kv, 480-volt transformers since several of these are fed from a single circuit. This switch will be key interlocked with the secondary circuit breaker to permit taking one transformer out of service without loss of service to other transformers fed from the same circuit.

It is apparent from the foregoing examples that transformer application principles are intimately bound up with the over-all system design so that the value of a coordinated system design becomes evident.

A few of the uses and application principles of transformers as components of systems have been described. Transformers will continue to serve the growing needs of the steel industry, and improved designs now available will provide even better service reliability than has characterized transformers in the past.

"POWER TRANSFORMER PREVENTIVE MAINTENANCE IN THE STEEL INDUSTRY"

By E. A. ELGE

Power Transformer Engineering

General Electric Co.

Pittsfield, Mass.

▲ VERY few users of electric apparatus are confronted with the maintenance problems of the steel industry. Problems unique to the steel industry in the maintenance of power transformers will be discussed first and will be followed by a general discussion of the maintenance and operation of old and modern power transformers common to all operators.

ATMOSPHERIC CONDITIONS

Steel mill atmospheres not only contain sulphurous and other corrosive compounds, but also considerable dirt carbon and magnetic particles in the form of dust. Thus, the special problem in the maintenance of power transformers is cleaning to prevent fouling of external insulating surfaces and control devices and protection against the deterioration of metallic surfaces.

Since the air contains magnetic particles, these particles which are sometimes in combination with carbon,

can be attracted by the magnetic field of a current-carrying conductor. Thus it is not uncommon to find a deposit on the underside of bushing and insulator petticoats as well as that normally expected on the top side. Hence the creepage surface is abnormally reduced and flashovers may occur under moist conditions. Insulating parts and contacts of control devices also may be impaired by deposits of the air-borne particles.

Reducing flashovers — Steel mill operators have tried various means to avoid bushing flashovers. Bushings of a higher voltage rating have been used to obtain extra creepage over the porcelain. Protective umbrellas or hoods have been placed over bushings to prevent particles of dirt from settling on the porcelain. Porcelain hoods have been used for this purpose and the glass globes of street lighting standards have been tried. In unusually dirty atmospheres a protective barrier or semi-enclosure on the prevailing windward side may be effective. Care must be taken not to interfere with the proper cooling of the transformers if enclosures are employed.

Cleaning porcelain — Regardless of which of the above means may be used to reduce bushing flashovers, a systematic schedule of cleaning is required to prevent flashovers. Frequent cleaning of bushing porcelains may be sufficient alone to eliminate flashovers.

Care should be taken to avoid excessive abrasive cleaning which might roughen or scratch the glaze on the porcelain, and make future cleaning much more difficult. A cleaning powder developed by us will be found very satisfactory in the majority of cases. This cleaner will not injure the glaze and is not injurious to the hands or clothes of workmen. The powder should be applied with sufficient pressure to remove the deposit. After the powder has dried, the surface should be wiped with a clean dry cloth, or flushed off with clean water. Lava soap or steel wool may be used instead of a cleaning powder.

Liquid cleaners such as naphtha or ammonia may be effective in certain cases. A dilute hydrochloric acid solution has been found useful in removing cement deposits, and also may be used for removing deposits of calcium carbonate which sometimes form on bushings near cooling ponds. A solution of one part of hydrochloric acid in 40 parts of water is recommended. When using the acid solution it is desirable to avoid contact of the solution with the cement or metal parts of the bushing, to prevent injury to these parts

After acid removal of deposits, the porcelain surface should be washed with a neutralizing solution consisting of four ounces of sodium bicarbonate in one gallon of water. The neutralizing washing should be followed by washing the surfaces with clean water.

At the present time the silicones are being investigated as a coating for bushing porcelains following cleaning. A successful coating material would make the deposit less adherent for subsequent cleaning.

Control devices — Fouling of control devices by dirt deposit or corrosive atmosphere in combination with moisture may not only cause failure of the device, but serious damage of the controlled apparatus. Control devices should be housed in dust-tight compartments and if not should be systematically inspected and cleaned.

Paint finishes — The corrosive atmosphere quickly rusts the steel at abraded spots or scratches in the transformer paint finish. A few minutes cleaning and touching-up of minor spots of rust as they appear will save manhours in repainting the whole transformers.

OPERATION AND MAINTENANCE

Operation of power transformers should be in accordance with the American Standards Association Standard C57.11, its loading guide C57.32 and specific instructions of the manufacturer. Devices furnished on transformers such as thermometers and pressure gages should be observed periodically. Trends away from a normal pattern of readings may give a warning of impending trouble. Corrective measures can be taken before serious trouble develops.

The extent and frequency of power transformer preventive maintenance in addition to the necessity of cleaning bushings is dependent on the size and importance of the transformer to the plant operation, tempered by the operator's experience and economics. Any preventive maintenance applies equally to spare transformers. To be effective as a spare, the transformer must be kept in good condition for immediate service. Spare bushings and other materials should be stored in a clean, dry place in readiness for use.

Transformer oil — Bottom oil samples from the main tank and samples from all compartments should be taken and tested yearly or at longer intervals depending on experience. Care in sampling and testing cannot be overemphasized. Samples should be taken on a clear dry day. Clean, dry, screw-cap, one-quart bottles should be used. It is preferable to place aluminum foil between the screw cap and the bottle opening. The sampling valve should be wiped clean. Allow sufficient oil to run out to clean any accumulated contaminants from the valve. The oil sample, when tested, should be at room temperature, preferably between 20 C and 30 C (68 F and 86 F). Testing at oil temperatures appreciably lower than room temperature is likely to give variable results which may be misleading and lead to needless filtering. Cold oil exposed to the air of a warm room is apt to cause moisture condensation.

Dielectric strength, acidity and visual condition should be checked. Dielectric strength tests should be according to ASTM procedure, in the standard gap having flat disk electrodes one inch in diameter, spaced 0.100 in. apart. Oil testing lower than 22 kv at room temperature should be restored to a dielectric strength of 26 kv or more by use of a filter press or oil purifier. Filtration of the oil with the transformer energized is not recommended. In modern transformers, the oil probably can be maintained in the vicinity of 30 kv or better.

If free water is found in the bottom oil sample, all such free water should be drained off before filtration is started. Check samples should be dielectric tested following warming up after return to service. If the dielectric strength drops, it is indicative of moisture still being retained by the solid insulating material and that the transformer should be dried.

Filter paper must be dry — Two common errors in handling filter paper have been observed many times. Filter paper drying ovens have been found packed so solidly that a period of weeks would have been required

to dry the paper. For effective drying, the sheets of filter paper should be spaced approximately ⅛ in. apart. The other error is over-exposure of dried filter paper. Filter paper exposed in normal atmosphere will reabsorb, in as little as five minutes, two-thirds of the moisture that it will ultimately take up. Thoroughly dried paper and rapid transfer of paper from oven to filter press are essential for effective filtration. If it is not possible to transfer the paper rapidly it may be immersed in clean, dry oil for transportation to the filter press.

Load ratio control — Manufacturers instructions must be followed in the inspection of load ratio control (tap changing under load) arcing contacts. The instructions state the number of operations which are permitted before inspection is required. Operation counters are provided with the equipment. Neglect of inspection of arcing contact wear may result in damage of the transformer windings in addition to the contactor itself.

Cooling coils — The life of transformer copper water cooling coils depends on many variables such as the chemical composition of the water, sediment, etc. It is good practice, therefore, to periodically test cooling coils for leaks, especially those which have been in service a number of years. Each coil, where there is more than one in parallel, must have the water removed by draining and blowing out with high pressure air (80 to 100 psi). Apply 100 to 150-psi air pressure to one coil at a time and observe the surface of the oil inside the transformer for air bubbles. The oil level should be 6 to 8 in. below the cover for proper observation of bubbles.

If a leak is discovered, the cooling coils should be removed for examination and perhaps repair. A three or four inch section straddling the point of leakage should be cut out, slit lengthwise and opened up. Examination will reveal whether the leak is a localized pin hole or caused by a general reduction in wall thickness from erosion or chemical action. Replacement of the cooling coil is recommended in the latter case.

Should a localized pin hole leak be found near a joint or an elbow, it is recommended that one or more nearby joints or elbows be cut out to determine whether or not trouble may be developing at these points. If there is any doubt regarding the general condition of a leaky cooling coil, the safest procedure is replacement.

Repairs of a cut out section may be made by using a copper sleeve having an inside diameter equal to the outside diameter of the cooling coils. The joints should overlap one-inch and be brazed with an alloy. One alloy requires no flux, only a clean joint.

Following repairs, the cooling coils should be given a 300-psi hydrostatic pressure to check for leaks before reassembly in the transformer. Transformer oil or water may be used for filling the coils.

Insulation resistance — Many operators use measurements of insulation resistance to check transformer condition. If the test is used for comparison with past readings in watching the trend of condition, it is important that each test on a given transformer be performed under as nearly identical conditions as possible.

Several factors affect insulation resistance measurements. Being a quantitative measurement, insulation resistance decreases with increase in transformer size for a given voltage rating. Dirty bushings and connected buses, especially in humid weather, will influence the results. Insulation resistance approximately halves for each 10 degrees C increase in temperature. The value obtained will increase with continued application of test voltage beyond that obtained in one minute or less time. Thus for meaningful results, periodic insulation resistance measurements should be made as follows:

1. On a clear, dry day.
2. On the transformer alone with buses disconnected.
3. Bushings must be clean.
4. Transformer should be at essentially the same temperature as on prior measurements.
5. A fixed time of test voltage application should be established.

OLD POWER TRANSFORMERS

Open-type — Moisture and oil sludging are maintenance problems experienced in old power transformers of the open-type. The open-type transformer Figure 1 (A) is ventilated to the atmosphere and therefore has an unlimited supply of oxygen to cause oil deterioration through oxidation.

At one stage in the history of open-type transformers 30 years or more ago, a single ventilator (breather) filled with calcium chloride was used. The purpose was to dry the air breathed by the transformer. Operators failed to maintain the devices. The calcium chloride became moist, caked and restricted breathing. Condensation and water accumulation in the transformer followed. A similar situation can develop with dessicants such as silica-gel or activated alumina if they are allowed to become saturated with moisture in the breather of an open-type transformer. It is preferable, therefore, to use two unrestricted breathers. The two breathers will permit free-circulation of air with the atmosphere and minimize moisture concentration in the interior.

Oil sludging — The major problem with open-type transformers is oil-sludging. Oil-insoluble sludge will impair the cooling of the transformer windings and if neglected will cause failure from over heating. When the oil acidity reaches a value of 0.6 to 0.7 mgKOH per gm of oil or there is evidence of appreciable sludge in the oil samples, an internal inspection of the transformer should be made. It should be noted that all oils in service do not deteriorate by oxidation in identically the same manner to yield insoluble sludge at the same level of acidity. If sludge is found on horizontal surfaces, steps should be taken to recondition the transformer. In water-cooled units, sludge will normally deposit first on the cooling coils which are the coldest points in the transformer.

Mere draining of the sludged oil from a transformer and replacement with new oil is uneconomical since the deterioration products retained by the core and coils will accelerate oxidation of the new oil. The transformer core and coils and the interior of the tank should be washed down with a high pressure jet of new oil to remove the deterioration products as far as possible. The transformer may then be filled with new oil or fuller's earth reclaimed old oil.

Oxidation inhibited oil — Many electric service company operators add an inhibitor to increase the life of the new or reclaimed oil following cleaning of an old

transformer. An acceptable inhibitor now on the market is di tertiary butyl para cresol, commonly called DBPC. The amount of inhibitor required is dependent on its compatibility with the particular oil involved and also in the case of reclaimed oil, the degree of reclamation. Inhibited new oil is also available.

Improved oil life may be obtained by equipping existing open-type transformers if feasible with one of the modern types of sealing from the atmosphere. Figures 1 (B) to (E) illustrate the various schemes used to exclude oxygen from the oil.

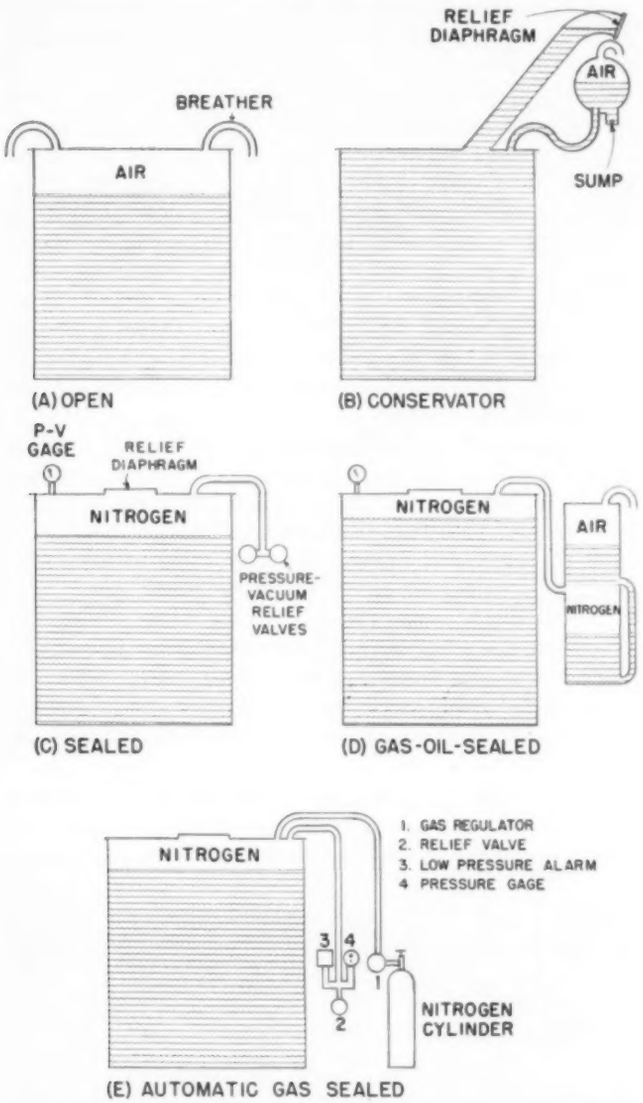


Figure 1 — Five types of power transformer tank construction are shown.

Old conservator-type transformers — Some of the first conservator type transformers Figure 1 (B) (prior to 1924) had trouble with oil sludging because of the use of a straight pipe connection between the main tank and the conservator. This allowed continual thermal circulation of oil between the main tank and conservator and hence relatively rapid oxidation of the oil. Replacement of straight conservator pipes by the "gooseneck" connection pipe shown in Figure 1 (B) is recommended. The bends in the "gooseneck" pipe form a thermal trap, preventing circulation of the hot transformer oil into the conservator.

MODERN POWER TRANSFORMERS

As mentioned previously modern power transformers are provided with one of several oil-preservation schemes to minimize atmospheric oxygen contact with the insulating oil and practically eliminate oil oxidation. Figures 1 (B) to (E) illustrate the common types of transformer tank construction used to preserve the oil from oxygen. The sealed construction, Figure 1 (C) is standard for power transformers 10,000 kva and smaller. Above 10,000 kva the automatic gas-sealed construction Figure 1 (E) is standard. The following discussion briefly gives the principal features of each scheme and a guide to their operation and maintenance.

Conservator-type — The conservator-type transformer, Figure 1 (B) has an auxiliary tank (conservator) located above and connected to the main tank by a reverse bend "gooseneck" pipe. The conservator is approximately 40 per cent full of oil at 25 C temperature. It has sufficient capacity so that it will not empty when the transformer is idle at the lowest ambient temperatures nor overflow at the highest permissible overload oil temperature. The "gooseneck" connection pipe prevents thermal circulation of hot transformer oil into the conservator. The oil in the conservator therefore is near ambient temperature and not subject to the oxidation of hot oil. Inter-change of oil between the conservator and main tank occurs only with expansion or contraction of the main tank oil.

Since the conservator oil level is above the top of the main tank, a positive oil pressure is always present in the tank. Leaks, with two exceptions, will be apparent by the stain of the outward flow of oil. The two exceptions are the pressure relief diaphragm and those gasketed bushing terminal caps which are above the conservator oil level. If the pressure relief diaphragm assembly is tight, most of the air in the relief pipe gradually will be displaced by the heated oil. The oil will rise above the level in the conservator and eventually will be seen part way up on the glass diaphragm. The tightness of the diaphragm assembly and bushing terminal caps may be tested by removing the conservator breather and applying 3 psi air pressure above the conservator oil level for about 24 hours.

Conservators are provided with a sump for the collection of moisture should unusual atmospheric conditions cause condensation. The sump should be checked for water accumulation. The frequency will be dependent on experience at the particular installation.

Sealed and gas-oil-sealed — The sealed and gas-oil-sealed types, Figure 1 (C) and (D) are similar in function. In the sealed construction a sufficient gas space is provided above the oil to limit the pressure and vacuum to 5 psi for small power transformers and 7½ psi for large. Present day power transformers are equipped with pressure and vacuum relief valves set at these values.

The gas-oil-sealed construction Figure 1 (D) uses a smaller space above the oil. Auxiliary space and a seal from the atmosphere is provided by a divided external expansion tank half filled with oil. A pipe connection runs from the gas space of the main tank to the top of the lower section of the expansion tank. The bottoms of the two expansion tank sections are connected together and the upper section is vented to the atmosphere. As the gas pressure in the main tank increases with oil

expansion and temperature, the oil is forced from the lower to the upper section of the expansion tank. The usual range of the gas-oil-seal transformer is 3 psi pressure to 1½ psi vacuum. Pressures in excess will be relieved by bubbling gas out through the oil in the expansion tank. Air will be bubbled in should 1½ psi vacuum be exceeded on rare occasions at low temperature.

Both sealed and gas-oil-sealed transformers are shipped with air in the gas space. Shortly after the transformers are placed in service and the oil is heated, the small amount of oxygen present permanently leaves the system by chemically combining with the oil. This results in a slight vacuum. The pressure in sealed transformers should be re-established by the addition of dry nitrogen in preference to dry air in accordance with the following table:

Liquid temperature, C	Approximate pressure, psi
25	0.0
30	0.5
35	1.0
40	1.5

Should older sealed transformers not equipped with pressure and vacuum relief valves be opened and resealed at an oil temperature substantially lower than 25 C, the gas space should be vented to zero pressure when the oil temperature is in the vicinity of 25 C. Otherwise excessive pressures at elevated oil temperatures might result.

When gas-oil-sealed transformers are placed in service initially, dry nitrogen or dry air should be added to the gas space until all the oil is forced into the upper section of the expansion tank. The sound of gas bubbling through the oil will indicate all oil is in the upper section. Thus as oxygen leaves the system, the reduction in pressure from loss in gas volume is compensated for by the oil head established in the expansion tank and positive pressure is maintained.

Most sealed and gas-oil-sealed power transformers are equipped with pressure-vacuum gages. Periodic observation of the gage is recommended for checking the tightness of the seal. Should the pressure fail to respond to an observed pattern in relation to changes in oil and ambient temperature, a leak in the seal is indicated. Leaks should be repaired as soon as possible since in some instances free water may be sucked into the transformer during a rain and a vacuum cycle. It is preferable to operate sealed or gas-oil-sealed transformers at a positive pressure at temperatures above 25 C. Should a leak develop, the initial result would be an outward flow of gas and reduction in pressure rather than an inward flow of air and possibly moisture.

Automatic gas-sealed — In the automatic gas-sealed power transformer Figure 1 (E), the system is always under a positive nitrogen pressure as long as the supply of nitrogen is maintained. A 200-cu ft cylinder of nitrogen gas is permanently connected to the gas space through a regulating valve which feeds in gas whenever the pressure drops below ½ psi. An exhaust pipe line connects to a pressure relief valve which automatically limits the pressure to 5 or 7½ psi depending on the size of the transformer.

A low gas pressure alarm is provided to give warning should a leak develop or should the supply of nitrogen otherwise become exhausted. A few operators prefer to have an extra alarm feature built into the high pressure gage of the gas regulator which will alarm when the gas cylinder pressure drops to around 200 psi.

Usually all the gas expansion space is provided above the oil in the main tank. In some instances because of shipping height limitation or other reasons, sufficient space in the main tank is provided for oil expansion only and an auxiliary gas expansion tank such as shown in Figure 2 is used.

The average large gas-sealed power transformer will

Figure 2 — View shows high voltage side of 25,000-kva arc furnace transformer.

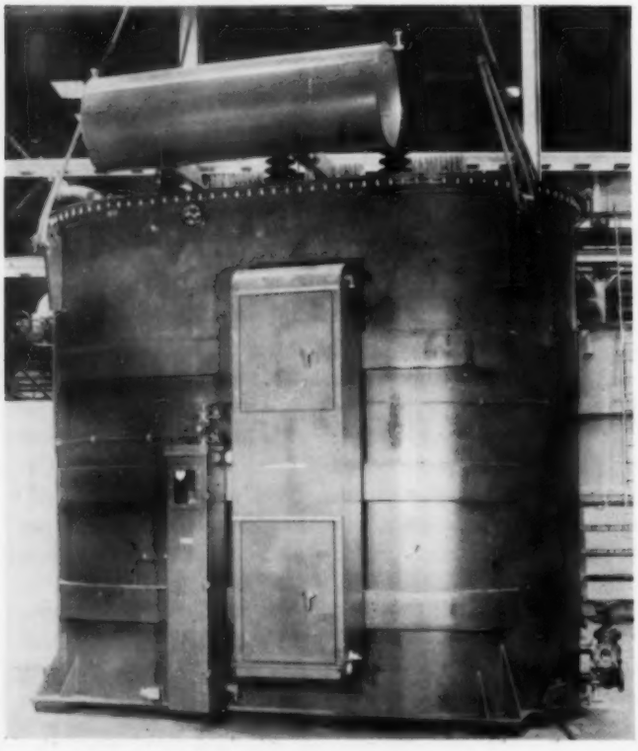
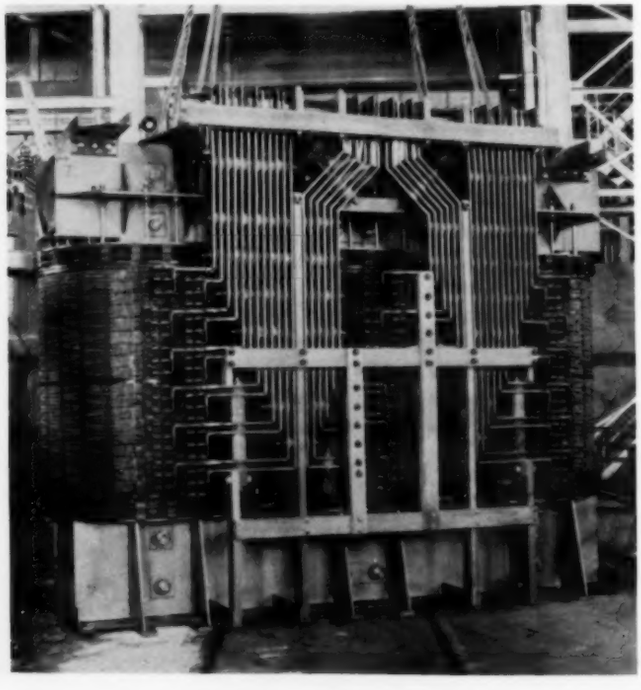


Figure 3 — View shows low voltage side of 25,000-kva arc furnace transformer interior.



use one to two 200-cu ft cylinders of nitrogen gas annually. A gas leak is indicated if the gas usage is in excess of this amount when operating pressures do not reach the setting of the relief valve (5 or 7½ psi).

A common point of gas leakage is at the nitrogen gas cylinder valve stem. This is caused by failure of the operator to fully open the valve. The valve is provided with a back seat which effectively seals off the stem side of the valve against the 2000-psi cylinder pressure when the valve is fully opened.

Arc-furnace transformers — The steel industry is the largest user of arc-furnace transformers such as illustrated in Figures 2 and 3. This particular transformer is equipped with an automatic gas seal and is force cooled by pumping the oil through external oil to water heat exchangers. Most arc furnace transformers are of the open-type (Figure 1A) and are water-cooled by copper cooling coils inside the tank.

Previous discussion of open-type transformers in regards to oil maintenance and leak testing of cooling coils apply to open-type, water cooled arc-furnace transformers. The practice of some operators of letting cooling water run when the transformer is out of service may be satisfactory to prevent freezing in winter months. However, there may be certain periods during the year when the oil and interior of an idle transformer may be cooled sufficiently below the ambient temperature to produce moisture condensation, and a consequent reduction in dielectric strength.

Referring to Figure 3 it can be seen that the low voltage circuit of a furnace transformer is composed of several paralleled windings. It is therefore important that the furnace bus connections which connect these windings in parallel, be of the best contact possible and that clamping pressure on the bus assembly be maintained. Loss of proper contact can result in a few of the several paralleled windings carrying the current and failing from overheating.

Because the voltage to an arc-furnace is only a few hundred volts, it is very easy to neglect cleaning of the insulation between buses at the connection to the transformer. Failures have occurred at this point. In making up the bus connections it is advisable to interpose one thickness of insulation in the center of each assembly 1 to 2 in. larger in outside dimensions than the remainder. This will provide a vertical surface for extra creepage distance and on which the mill dust cannot be deposited directly.

Most furnace transformers are equipped with motor operated tap-changers. The motor drive control is electrically interlocked, and in some cases mechanically interlocked in addition, to prevent operation when the high voltage side circuit breaker is closed. At least monthly checks of the control is recommended. The control devices must be kept clean and all contact making parts must be in first class condition. A suggested operational check would be as follows: the high voltage backup circuit breaker first should be opened to deenergize the circuit. The furnace circuit breaker then should be closed and various furnace operator short-cuts tried to see if the control can be made to malfunction with the breaker closed. Operation of the tap-changers with the transformer energized can result not only in tap-changer failure, but also serious damage to the transformer windings.

NON-INFLAMMABLE INSULATING LIQUID TRANSFORMERS

Askarel is a non-inflammable insulating liquid used in place of mineral oil in transformers that are installed indoors or in hazardous locations. Askarel immersed transformers are of the sealed construction without pressure and vacuum relief valves. With a few exceptions the same attention should be given their maintenance as oil-immersed transformers. Since the liquid is heavier than water, moisture and impurities tending to affect dielectric strength will in general, be at the top of the liquid. Therefore, samples should be drawn from the sampling valve provided near the surface. Should the dielectric strength fall to 25 kv or lower it should be restored by filtration to 30 kv or higher. Filtration should draw the liquid from the top and return at the bottom of the tank since free-water and most of the sediment will be at the top.

Insulation resistance or insulation power factor tests do not have too much significance in checking the condition of askarel-immersed transformers. The material has a greater solvent action than oil on the selected organic insulating and construction material in the transformer. In fact certain materials used in oil cannot be used in askarel. The minute amount of solubles from the construction materials tends to increase the power factor and decrease the resistivity with no affect on dielectric strength. This in turn increases the power-factor and decreases the insulation resistance of the overall transformer.

Since 1944 a trace of tin tetraphenyl has been added to askarel to act as a scavenger for free hydrogen-chloride gas should any be present because of a failure. Under extreme cold conditions, some of this tin tetraphenyl may float on the surface as a milky-white crystalline material. This is not detrimental and should not be construed as the presence of moisture. The material will re-dissolve on rising temperature.

Askarel may be handled in the same manner as oil with the following exceptions. Continued exposure may produce local skin irritation. Cleanliness by workmen handling it is one safeguard against such effects. Ordinary medicinal washes will remove irritation caused by askarel contact with an open cut or skin abrasion. A drop of castor oil will neutralize irritation caused by contact of the liquid with the eyes. As with most volatile materials, exposure to concentrated vapors in an unventilated room should be avoided. Askarel must be handled in containers, pipes, all-metal hose, etc., that are free from oil, grease, pitch or other foreign materials. Trichlor-tetrachlor benzene blend is the most satisfactory cleaning agent. This is the volatile constituent of the askarel and hence is non-inflammable. Naphtha may be used in an emergency, but necessary precautions must be taken against the fire and explosion hazard involved. It is desirable that all equipment used in storing and handling askarel be maintained for exclusive use with it, as it is extremely difficult to remove all traces of oil or other contaminants from equipment of this type.

In the event of failure of an askarel transformer, it is recommended that the liquid level be raised sufficiently to cover the core and coils; the transformer promptly sealed from the atmosphere in any event and the manufacturer consulted immediately on the procedure

to follow. Should it not be desired to field reclaim arced or contaminated askarel, negotiations for reclamation may be directed to the manufacturer.

MINOR REPAIRS

Locating leaks — Insulating liquid leaks tend to stain such large areas of the transformer that the exact point of leakage is not always apparent. The questionable areas should first be washed with petroleum spirits, naphtha or non-leaded gasoline. The area should then be covered with chalk, cement dust or white wash. The point of leakage will show as a dark spot.

When the leak is in the gas space above the oil it may be located by raising the nitrogen gas pressure to 3 psi and observing for bubbles when a solution of equal parts of liquid soap and water is applied to suspected areas. One method of applying the soap solution is with an oil squirt can.

The halogen leak detector is an effective means of locating gas leaks. One-half per cent to two per cent by volume of the halogen gases sulfur hexafluoride or freon No. 12, is introduced as a tracer into the transformer gas space. Nitrogen is added to about 3 psi. One and one-half per cent by volume of the tracer will raise the total pressure about 0.3 psi.

The probe of the detector is passed over suspected areas. A signal is given by the detector when the halogen gas is encountered at the point of leakage.

Repairing leaks — When repairing leaks by welding, brazing or soldering, fire extinguishers of the carbon dioxide or carbon tetrachloride type should be kept handy. An inert atmosphere of nitrogen gas should be maintained inside the transformer if the leaks to be repaired are above the oil level. If the leak is three or more inches below the oil level, special precautions are usually unnecessary because of the cooling effect of the oil in contact with the metal. Because of this cooling effect it is practically impossible to gas weld or braze below the liquid level. Arc welding is recommended.

A problem in repairing leaks below the oil level is stopping the outward flow of oil during the arc welding. In some instances the oil flow may be stopped by peening. A vacuum sufficient to overcome the oil head is a successful method of stopping outward oil flow. Vacuum may be obtained with a small portable pump or, as one resourceful person did, by connecting the gas space of the transformer to the intake manifold of an idling automobile engine. Care should be taken to apply only enough vacuum to overcome the oil head. Excessive vacuum may damage the tank. The pounds of vacuum required can be determined by dividing the oil head in inches by 31. Outward flow of oil at a leak also can be stopped by tightly sealing the top of the transformer and draining oil from the bottom until flow at the leak ceases.

Gasketing — All our modern power transformers are gasketed with nitrile rubber which is suitable for either oil or askarel. Positive stops or grooves are provided to limit the compression to two-thirds the original thickness, i.e., $\frac{3}{8}$ in. thick gaskets are compressed to $\frac{1}{4}$ in. thickness. The material requires no compound to effect a seal and the gaskets are re-usable following opening of mating parts.

In re-using nitrile gaskets following opening of doors, manholes, etc., it should be made certain that oil spilled on the outside of the gasket in grooves, between strip stops and the gasket or in tapped holes is removed. Oil retained in these locations will stain a large area and give a false indication of a leak. Nitrile rubber also is used as stuffing for radiator valve stems and shaft seals on load ratio control.

Nitrile rubber gaskets are not readily adaptable to old transformers designed for composition cork gaskets. A higher compressive force is required for which existing bolt spacing may not be adequate. Flatter and smoother surfaces are also required.

The effectiveness of composition cork and cork and synthetic (corprene) gaskets seals is wholly dependent on their being properly treated with compound. The actual seal is the skin of compound between the mating parts across the inner edge of the gasket.

Each manufacturer has its recommended cork gasket compound.

After the cork or corprene gaskets have been cut and fitted and joints scarfed 5:1, the pieces should be entirely coated with compound and allowed to dry. A coat of compound also should be applied to the mating parts and allowed to dry.

The next step is to apply a coat of compound to the largest of the mating parts and a coat to the side of the gasket to be placed against this part. When the compound has dried so that it will not adhere to the fingers, assemble the gasket to the coated part. Make up the scarfed joints at this time and weight or clamp the gaskets for at least 30 minutes. A coat of compound should then be applied to all exposed surfaces of the gasket making certain that the inner edge is well coated. The other mating surface also should be coated. When the compound is tacky, assemble the mating parts.

The joint should be tightened in small increments going over the bolts several times to compress the gasket as indicated in the table below. Allow two to six hours to elapse between the first and second tightenings and keep the insulating liquid away from joint until the final tightening.

Cork gasket compressions in fractions of original thickness should be:

	Soft cork	Hard cork
First tightening	$\frac{1}{2}$	$\frac{2}{3}$
Second tightening	$\frac{1}{3}$	$\frac{1}{2}$

Cleaning cooling coils — Nearly all cooling water will, in time, form scale or sediment in cooling coils of water-cooled transformers. This condition is indicated by an increase in oil temperature and a decrease in water flow (load conditions and water pressure remaining the same). Before attempting cleaning, it should be assured that there are no leaks in the coils.

Scale and sediment can be removed from the cooling coils without taking the coils out of the tank. The inlet and outlet water piping should be disconnected and these joints temporarily piped to a point several feet away from the transformer where the coils can be filled and emptied safely. Special care should be taken to prevent entry of cleaning solution, water or dirt into the transformer.

After draining all the water from the cooling coils, they should be pumped full of 1.10 specific gravity hydrochloric acid solution. (Equal parts of commer-

cially pure concentrated hydrochloric acid and water will give this specific gravity.) The chemical action which takes place when the acid enters the coils often forces acid, sediment, etc., from both ends of the coils. Therefore, it is advisable to leave one end of each coil partially open to prevent abnormal pressure.

After the solution has been in the coils about an hour, it should be drained and the coils flushed thoroughly with clean water. If all the scale is not removed, the operation should be repeated until the coil is clean, using a new solution each time. The number of times the process is repeated will depend on the condition of the coils. Usually one or two fillings will be sufficient.

Following cleaning, the cooling coils should be air pressure tested as described previously.

Painting — The durability of any paint finish depends largely on how well the surface has been prepared before paint is applied. If the condition of the transformer tank is bad it is usually necessary to remove the paint entirely.

There are three practical methods of preparing transformer surfaces for refinishing in the field:

1. Sandblasting does a thorough job of removing paint, rust and dirt.
2. Wire brushing. Flexible shafts with wire brushes have been developed for the removal of flaky paint, scale and rust from almost any location on a transformer tank or accessory.
3. Chemical removers. Paint removers, such as strong solvents or alkalis, will soften paint and aid in removal. This type of paint removal becomes more difficult with the new synthetic baked finishes.

After chemical remover has been used, the surface should be thoroughly cleaned and all waste material removed from around the transformers.

If alkali cleaners are used, the surface should be thoroughly rinsed with clean water. This should be followed with a rinse of clean water containing one gram of potassium dichromate per gallon to neutralize the alkali and inhibit rust formation. When water is used in the cleaning operation, the tank should be dried quickly and completely.

Where only partial cleaning of a transformer is necessary, sandblasting or chemical cleaning is not recommended because of possible damage to adjacent painted areas that are in good condition. Cleaning by mechanical means such as wire brushing, sandpapering or scraping is preferred. Edges of scraped areas should be bevelled by sandpapering.

Weak solvents such as mineral spirits, turpentine substitutes or other petroleum thinners should be used for removal of oil and dirt. Strong solvents such as acetone, ketones, etc., should be avoided as they will affect the good paint.

After cleaning by any of the above methods the surfaces should be painted as quickly as possible.

A primer coat and at least one finish coat of paint should be applied. Spraying is recommended for all accessible areas and flow painting for inaccessible areas. The melamine paints used on our modern power transformers have proven to be excellent. The orange primer acts cathodically on the steel to inhibit corrosion. The blue-grey finish paint also may be used inside oil-immersed transformer tanks. At least 72 hours air-drying at 70 F is required before contact with oil. No paint should be used in contact with askarel.

FAILURES

Transformers have been needlessly damaged by reclosing several times on an initially minor internal failure. Each successive reclosure may add substantially to the amount of damage to be repaired. Internal failure should be suspected and the transformer checked before re-energizing if the transformer relayed out and no cause external to the transformer is apparent. All operating conditions at the time of the disturbance should be noted, such as load, tap position, temperatures and anything unusual. The following inspections and checking are suggested:

1. Operation of the pressure-relief device, especially if some oil is discharged is indicative of internal arcing.
2. Top and bottom oil samples should be taken, inspected and tested. Discoloration by carbon is evidence of arcing. Low dielectric strength or presence of free water in the sample may give a clue to the cause of the trouble.
3. Inspection of the interior through the manholes will also show whether or not the oil contains carbon. Presence of small bits of partially burned insulation on the upper horizontal surfaces is usually conclusive evidence of trouble.

When the above checks are not conclusive, or it is desired to locate the point of damage, the following checks may be made:

1. Insulation resistance measurements may be used to determine which winding is involved should the failure be between windings or to ground and to check the continuity of each winding. Comparison of measurements with prior measurements on the same transformer or duplicate transformers also may be helpful. Insulation power-factor also may be used to check against prior readings or against duplicate transformers.
2. A low-voltage ratio check on all tap positions in many instances will disclose the defective area of the transformer. If the transformer is three phase with the neutral available, each leg may be checked line to neutral, single-phase, and compared.
3. Copper resistance measured with a low-reading bridge may disclose partial winding faults. Again the readings may be compared with prior measurements or those taken on a duplicate transformer. Three-phase transformers may be compared phase to phase.

If there is any doubt whether a failure has occurred, the manufacturer should be consulted before re-energizing the transformer.

Most of the foregoing discussion on the maintenance and operation of power transformers is applicable to all users. The steel industry, however, occupies an unenviable position among operators of electric apparatus where cleanliness of the exterior of power transformers is of equal importance to that of the interior. In the steel mill corrosive atmosphere containing magnetic and carbon particles, it is imperative that bushings, insulating surfaces and control devices be systematically cleaned to achieve power transformer service continuity.

Program
of the
American Iron and Steel Institute

. . . . in reviewing problems of iron and steel production, leading operators of the steel industry, at the sixty-second general meeting of the American Iron and Steel Institute held in New York City on May 26 and 27, 1954, presented a number of interesting papers . . . . special panels were held on quality control, stress corrosion, public relations, and industrial relations . . . . some of the papers are abstracted here . . . .

"EXCERPTS FROM THE SCHWAB MEMORIAL LECTURE"

By DR. MERVIN J. KELLY
President, Bell Telephone Laboratories
New York, N. Y.

▲AUTOMATION—the use of advanced electronic art to control manufacturing processes and to solve business problems—is probably the century's greatest contribution to the reduction of man's burden.

Such automation through electronic digital systems will relieve man from the more routine and repetitive mental operations of the civilian economy. Clerical operations such as accounting, payroll, stock-keeping, production control, sales analyses, and market forecasts, are areas where electronic automation will supply business with a new tool of large economic significance.

The manufacture of radio and television sets can be programmed and made completely automatic by electronic digital computer techniques, while complex chemical processes like those required to produce synthetic materials can be placed under complete automatic control by similar electronic systems.

The advantages automation brings to the civilian economy are rooted in scientific research and technology applied originally to military devices. Modern anti-aircraft guns and guided missiles are controlled by electronic computers which gather information, assess it, and program a course of action for the weapons in fractions of a second.

These automatic techniques were developed in the laboratories of industry, government and the universities, under government sponsorship, at an accelerated tempo due to the demands of modern warfare. Business and industry can now apply them for the benefit of mankind in many routine and monotonous office and factory operations.

There is probably no area of production where automation through digital methods will not provide economies. The completely automatic factory can, indeed, be foreseen.

These advances in business, banking, merchandising and manufacturing areas will not come as a revolution of present methods but rather as a hard-earned, step-by-step evolution.

Advancing the date of introduction into the civilian economy of new materials and new facilities is one of the most significant contributions that the military development programs make to the civilian area. The almost unlimited financial support government can give to projects of great promise to the military, at the same time gives materials and facilities to industry years

earlier than would be possible under peacetime conditions.

Atomic weaponry is another technical area where research for the military promises major contributions to civilian life. These contributions will be of greater significance to mankind than those of any other military research program.

As knowledge of the atomic power reactor problems, technical and economic, has grown, hope for an ultimate economic role of atomic power in the civilian economy changed to confidence. Also the estimates of the time interval before economic application would be possible have become steadily less. A new source of energy essential to the life of a highly industrialized society will soon be available. It insures adequate power for mankind for many hundreds of years.

It has been estimated that if all the economically recoverable uranium and thorium of the world were employed, they would provide an energy source adequate for world consumption for thirty centuries at present consumption rates.

"SOME STATISTICAL METHODS USED IN STUDIES OF STEEL PLANT OPERATIONS"

By A. P. WOODS

Research Engineer

Research Laboratories

Armco Steel Corp.

Middletown, Ohio

▲AMONG the many important groups of problems facing the management of a steel plant, there are two whose solution can be more closely approached by studies involving the use of statistical methods. These problems are:

1. How to use the presently available plant equipment most efficiently.
2. How to spend any money available for plant improvement and expansion most effiectively.

The studies necessary to solve these problems often require laboratory, pilot plant, or production plant experimentation. The use of statistical methods increases both the amount and accuracy of the information obtainable from such experimentation.

In any manufacturing process raw materials (e.g., iron ore, coal, steel scrap), after entering the plant, undergo a series of changes in various pieces of equipment (e.g., blast furnace, coke ovens, open hearth furnace, rolling mills) and finally leave the plant as a finished product (e.g., steel coils and sheets). At each step in the operation the condition of the equipment being used and the product being processed may be defined by a number of operating and product factors. These are of two kinds:

1. Variables are factors whose location is known and whose magnitude is measured (e.g., rate of open hearth furnace fuel consumption in Btu/hr).
2. Attributes are factors whose location is known but whose magnitude is not measured.

In an investigation of a process attributes are defined by stating their location and studied by comparing them with other attributes serving the same purpose (e.g., comparing three different designs of open hearth fuel burners, comparing two different sources of the same raw material). The operating factors (those which define the equipment and its operation) differ from one another in the ease with which they may be controlled at a desired level by the operator.

1. Some factors are under the control of the operator within the limits of the equipment or the supply available (e.g., the rate of fuel consumption).
2. Some factors can be made more controllable after the addition of more capital equipment (e.g., the rate of scrap charging into the open hearth furnace).
3. Some factors are controllable only indirectly by controlling other operating factors (e.g., the preheat temperature of the combustion air entering the open hearth furnace chamber).

All product factors (those which define the condition of the product in or flowing through the equipment) are controlled indirectly (e.g., the chemical analysis of the steel produced). The assumption is made that variations in the product factors are due to variations in the operating factors and in the raw materials entering the plant.

The efficient use of the presently available plant equipment implies that the product factors are being controlled at a desired level that gives a maximum profit to the company while supplying satisfactory quality to the customer. A study of presently existing operations to learn what product and raw material factors cause variations in production rate, quality and cost, and how these factors may be controlled gives management much of the information it needs to operate the plant efficiently.

The effective spending of plant improvement and expansion funds implies that customer needs for more product, better quality, lower prices or new products are being met in a way that will give maximum company earnings for each equipment dollar spent. The following types of investigations will furnish some of the information management needs if effective spending of funds is to occur.

1. A study of presently existing operations to learn what equipment bottlenecks exist that would prevent improvement in production rate, quality or cost reductions should changes in operations be made.
2. A study of the fundamentals of each piece of equipment to learn its most efficient design (e.g., model studies of open hearth furnaces involving dimensional analysis).
3. Trials of new processes or pieces of equipment to compare their performance with present operations (e.g., the development of the continuous hot dip process for making galvanized steel coils to replace the old hot dip sheet process).

4. Development of new products and processes to make them (e.g., the development of grain oriented silicon steel for transformer cores).
5. A study of the chemical, physical or mechanical properties of products or processes to obtain a better description of the product or a law governing the process. This information is then used in investigations of type 2, 3 and 4 mentioned above (e.g., the physical properties of steel, new analytical methods, and thermodynamic properties of elements, compounds and reactions).

There are two types of experimental procedures used in these investigations.

1. The controlled experiment where all or most of the factors being studied are held close to pre-arranged values. The effects of the various factors on the dependent variable being studied can be easily obtained by analysis of variance methods.
2. The uncontrolled experiment where most of the factors being studied vary over a range of values. The data obtained must be analyzed by correlation methods. Simple or multiple correlation will show the average effects of the independent factors, but the correlation methods must be modified to show interaction.

   Interaction between two independent variables exists when the effect of one of them on quality, for example, changes when the level of the second independent variable is changed (e.g., the effect of sulphur on the hot rollability of steel changes as the per cent manganese present decreases).

"SIGNIFICANCE OF MINOR ELEMENTS IN IRON-BEARING RAW MATERIALS FOR INTEGRATED STEEL PLANTS"

By C. B. JACOBS

Manager, Raw Materials Dept.

J. F. ELLIOTT

Assistant Superintendent

Open Hearth and Blooming Mills Div.

and

M. TENENBAUM

Assistant Superintendent

Quality Control Dept.

Inland Steel Co.

Chicago, Ill.

▲ AS has been shown, the basic ingredient for steelmaking, iron ore, can contribute varying quantities of minor elements to the blast furnace and steelmaking process. See Table I. The net amount of each minor element contained in the final steel product will be the sum of the amounts brought in by the iron ore and other primary raw materials, such as scrap, coke and limestone, minus the quantities removed in the slags, exhaust gases and dust.

Figure 1 shows schematically the essentials of the customary flow sheet for an integrated steel plant. Indicated thereon are the various minor elements that generally may be encountered in the raw materials. Also shown are those elements which migrate in part or wholly to the waste products, gas, dust, and slag, and

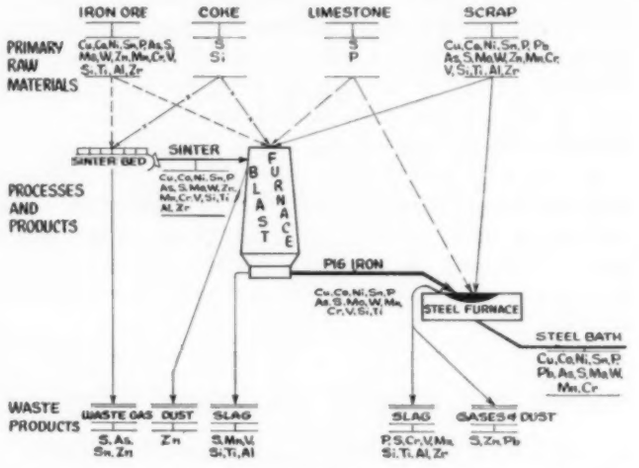


Figure 1 — Chart shows flow of minor elements in integrated steelmaking operations.

those which may pass partially or wholly into the metallic phase and ultimately will be found in the steel product.

The underlying consideration controlling whether or not an element in the raw materials will ultimately be present in the refined steel is the oxygen level maintained in the reaction zone of each process.

FACTORS CONTROLLING BEHAVIOR OF MINOR ELEMENTS

In both the blast furnace and the open hearth, the metal bath is the carrier for all elements which ulti-

Figure 2 — Charts show that recovery of minor elements in steelmaking depend upon stability of oxides.

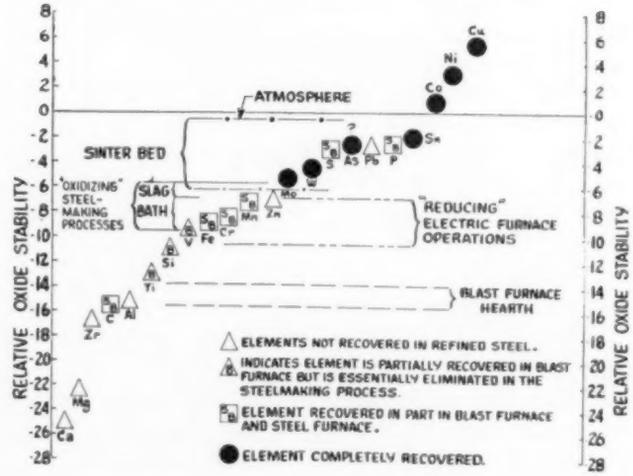


TABLE I

Summary of Elements Found in Iron Ores Used by the American Iron and Steel Industry

Analyses, weight per cent

Source	Fe	P	SiO_2	Al_2O_3	Mn	S	CaO	MgO	Ti	V	Cr	Zn	Mo	As	Pb	Sn	Ce	Ni	Cu
Cuyuna	55.83	0.367	24.82	4.60	12.92	0.093	0.84	0.35	0.090	0.009	0.019	0.006	0.005	0.006	—	—	—	0.002	0.011
	32.75	0.104	10.61	0.94	0.47	0.008	0.15	0.07	0.005	*	*	*	*	*	—	—	—	*	*
Gogebic	59.93	0.112	17.48	3.41	1.53	0.040	0.56	0.70	0.040	0.10	0.10	—	0.002	0.10	—	—	0.10	0.10	0.10
	52.57	0.043	4.50	1.51	0.21	0.005	0.24	0.15	0.035	0.005	0.01	—	*	0.003	—	—	0.01	0.002	0.008
Marquette	61.57	0.180	44.98	4.66	2.46	0.210	0.93	1.53	0.325	0.020	0.010	0.005	0.005	0.006	*	*	*	0.006	0.012
	37.13	0.014	5.93	0.59	0.06	0.008	0.28	0.16	0.03	0.004	0.001	0.002	0.0018	0.002	*	*	*	0.002	0.006
Menominee	59.60	0.465	44.57	3.97	5.69	0.259	1.49	4.20	0.235	0.035	0.015	0.041	0.004	0.014	*	*	*	0.020	0.025
	37.11	0.015	4.33	0.89	0.05	0.006	0.24	0.18	0.065	0.016	0.002	0.012	0.0012	0.005	*	*	*	0.009	0.007
Mesaba	63.20	0.118	21.68	11.48	5.48	0.073	0.72	0.21	0.21	0.010	0.018	0.007	0.005	0.008	*	—	*	0.005	0.019
	49.07	0.028	3.18	0.45	0.07	0.005	0.09	0.07	0.008	*	*	*	*	*	—	—	—	—	—
Vermilion	62.06	0.110	10.65	4.89	0.15	0.080	1.10	0.81	0.07	0.10	0.10	0.01	0.01	0.10	0.01	0.01	0.01	0.10	0.10
	55.34	0.060	4.90	2.22	0.07	0.034	0.17	0.18	*	0.01	0.01	*	*	0.01	*	*	*	0.01	0.01
Steep Rock	60.69	0.033	10.35	2.36	0.28	3.60	0.23	0.22	0.30	0.012	0.072	0.007	0.004	0.03	—	—	0.10	0.02	0.10
	50.80	0.019	2.97	0.98	0.10	0.016	0.08	0.04	0.01	0.006	0.013	*	*	*	—	—	—	*	*
Michipicoten	51.54	0.027	11.79	2.91	2.90	0.098	3.02	8.40	0.075	0.009	0.004	0.010	0.003	0.024	*	0.075	*	0.004	0.025
	49.31	0.016	9.81	1.59	2.79	—	2.98	7.46	0.056	0.005	0.001	0.005	*	0.020	*	*	*	0.002	0.005
New York State (Sinter)	66.20	0.183	7.93	4.48	0.32	0.034	0.92	0.39	2.59	0.056	0.020	0.010	0.005	0.0005	—	—	0.002	0.012	0.014
	59.40	0.010	4.17	1.39	0.10	0.007	0.31	0.22	0.32	0.012	0.010	0.002	0.002	—	—	—	—	0.008	0.003
Eastern Penna. (Cornwall)	62.83	0.005	5.10	1.52	0.072	0.031	1.40	1.60	0.08	0.011	0.013	—	—	—	—	—	—	0.013	0.021
Texas (Lone Star)	47.52	0.18	15.34	6.90	0.32	0.10	0.15	0.030	0.026	0.032	0.020	—	0.004	0.013	—	—	—	0.008	0.004
California (Eagle Mt.)	55.00	0.080	11.00	1.60	0.08	0.40	1.80	3.50	0.13	0.003	0.005	—	0.001	0.005	—	0.003	0.020	0.005	0.05
Wyoming (Sunrise)	52.40	0.090	12.68	0.751	0.09	0.036	1.25	0.36	0.07	0.020	0.013	0.058	0.004	0.011	—	—	0.002	0.046	0.005
Utah	57.81	0.310	4.29	1.17	0.06	0.070	—	—	—	—	0.001	—	—	0.019	—	—	—	0.005	0.014
Tenn. C & I (Red Ore)	37.70	0.32	15.50	3.00	0.15	0.030	13.35	0.60	0.080	0.018	0.002	0.001	0.001	—	0.006	0.001	0.001	0.003	0.004
Tenn. Copper Co. (Sinter)	69.00	0.005	1.50	0.45	0.10	0.07	0.10	0.60	—	0.008	—	0.20	0.01	—	—	—	0.05	0.01	0.12
Venezuelan	64.85	0.13	0.98	2.45	0.10	0.043	0.017	0.084	0.20	0.006	0.009	—	*	*	—	—	*	—	0.003
	63.00	0.05	0.80	1.80	0.08	0.020	*	*	0.09	—	—	—	—	—	—	—	—	—	*
Chile (Tofo)	60.30	0.042	7.49	1.76	0.09	0.021	1.41	2.00	0.59	0.28	0.008	—	—	—	—	—	—	0.015	0.010
Labrador	58.00	0.058	8.40	0.84	1.30	0.012	0.17	—	0.005	—	0.001	0.008	—	0.001	—	—	0.001	—	0.005
Brazilian (Itabira)	68.50	0.035	0.39	0.76	0.05	0.008	0.01	0.03	0.014	—	0.008	0.005	0.004	—	—	—	—	0.006	0.018
Swedish (Kiruna)	66.35	0.485	1.97	0.50	0.11	0.006	2.24	0.94	0.040	0.074	—	—	0.010	—	—	—	0.022	0.009	0.004
Liberian (Bumi Hill)	69.50	0.055	0.11	0.19	0.16	0.011	0.03	0.15	0.04	—	0.012	0.002	0.003	—	—	—	—	0.002	0.004

— None. * Trace. Paired figures show range of concentration found in samples from the range.

mately may be in the refined steel. The presence of an element in the bath will be governed largely by whether it is wholly, partially or not at all oxidized into the slag, waste gases or dust.

Whether an element is lost as the oxide or reduced and recovered in the steel is governed primarily by four factors:

1. Relative oxygen level of the process.
2. Intrinsic stability of the oxide.
3. Chemical behavior of elements in bath.
4. Chemical behavior of the oxide in the slag.

The relative oxide stabilities of elements are shown on Figure 2 by several symbols; an open triangle indicates that the element is wholly removed in both the blast furnace and steelmaking processes, an open triangle containing the letter "B" shows that an element is reduced into the metal in the blast furnace but that it is not recovered at all in refined steel in the steel-

making furnaces, a square containing the letters "SB" denotes an element which is partially reduced into the metal baths of both the blast furnace and steelmaking furnaces, and a filled circle shows that all of the element in the various raw materials in the steelmaking system will be present in the refined steel, that is to say, recovery is 100 per cent. It is evident where partial recovery is experienced, that adjustments in slag basicity (or acidity), temperature, and the weight ratio of slag to metal may have some influence in the recovery of an element.

At this point, it is to be noted that theoretically no element can be completely removed from the system or completely recovered in the metal.

To summarize, the iron bearing raw materials being used in integrated steel plants introduce many elements into the steelmaking system other than those which are ordinarily considered in establishing marker values. See Table I. Some of these elements are eliminated in steelmaking while others carry through as residual elements in the finished steel product. Included in this latter group are copper, nickel, cobalt, tin, molybdenum, tungsten, sulphur, phosphorus, arsenic, manganese and chromium. It would not be realistic to try to set up rigid limits for the tolerable level for each of these residual elements. Actually, the tolerable limit for any residual element is determined by the products being made at a given steel plant and the relative levels of all elements in the total raw material supply.

The effect on product properties is an important factor limiting the level of any residual element that can be tolerated in a given steel plant. It is important that this limit be set below the point where product performance is adversely affected. Since hot working properties and finished product ductility are common requirements of all steel products, the percentage of any element that can be tolerated would be regulated by the effect on these properties. Accordingly, it may be concluded that raw materials introducing significant percentages of any elements that have a detrimental effect on these properties would be limited in their acceptance.

Integrated plants generally make steel for a wide variety of products and applications. Few such plants are designed so that specific smelting facilities can be allocated to produce the iron needed for the manufacture of a single final product in order to control some minor elements that may persist through the steelmaking system. Thus, even though it might seem advantageous to use an ore containing elements that are unique to a few selected applications, the loss in flexibility, the lack of uniformity of operations, and the contamination of other products generally militates against such a procedure. As a result, each plant must establish its own limits based on the lowest maximum levels that can be tolerated in any of its major products. It has been shown that reasonable levels of minor elements are being met by the existing sources of raw materials. However, the levels that can be tolerated in many plants meeting rigid specifications are so low that serious consideration must be given to the minor element content of any new raw material before it can be accepted for use in integrated steel plants.

"CONSIDERATION OF HEATING, ROLLING AND ANNEALING AS FACTORS IN THE CONTROL OF QUALITY OF COLD ROLLED SHEETS"

By HUBERT C. SMITH

Vice President

Quality and Research

Great Lakes Steel Corp.

Ecorse, Detroit, Mich.

▲ IT is believed that every good blooming mill superintendent has at some time complained about poor ingots coming to him to be heated and rolled. Similarly, hot mill superintendents believe that a better slab would permit them to roll a better hot band. Cold mill supervision knows that inferior hot bands result in inferior cold rolled sheets. How vociferous the complaint is a matter of individuality. The very self evident point is this—in the flow of raw materials into the blast furnace and hot metal and scrap to the open hearth, a good ingot must result.

Soaking pit heating may be an operation which can be counted on to contribute everything possible and never be harmful. The first requisite in obtaining such a safety factor is adequate capacity, then knowledge of how to do the job properly and lastly the sense of responsibility to see that the job is done. In summary, for proper heating are needed both adequate capacity and personnel. Control instruments are valuable. There is no substitute, however, for a blanket of scale which sheds readily, and uniformity of heat at the right temperature to permit rolling with a minimum of breaks—a minimum which should be zero.

Shape, gage, surface, scale condition and metallographic structure are all controllable to a greater or lesser degree on today's continuous hot mills, depending upon individual installations, skill, instrumentation and the recognition of what is needed in a hot band to be converted into cold rolled sheets. Finishing and coiling temperatures are serious factors in producing an end product which is drawn severely into a stamping, as are scarcely discernible defects such as rolled-in scale or scratches. There are 231 table rollers which must be maintained so that they all turn freely. High pressure sprays must properly cover the entire surface of the partially rolled band or scale streaks result. Any variation in gage from front to back of the band means an abrupt change in gage in the welded coil at the weld. Cooling sprays affect the hardness of the hot band as well as subsequent pickling.

Quality factors in tandem mill rolling are generally dependent upon skill and instrumentation. Such factors as the amount of cold reduction are generally standardized. In our practice we specify 60 to 65 per cent cold reduction for rimming steel and 38 to 45 per cent for aluminum killed. Most of the reduction is effected in the first stand. The work rolls in the last stand are blasted so as to produce a dull surface. This dull sur-

face is helpful in avoiding the sticking or welding together of adjacent layers in annealing and is desirable when drawing stampings in dies.

Most annealing of cold rolled sheets, both cut lengths and coils, is performed in radiant tube furnaces. The product is protected by an atmosphere which is slightly reducing in character. Heat transfer is increased by fans in some installations.

Pyrometric control is most important in achieving softness and ductility while avoiding grain coarseness and sticking or welding of adjacent layers. Thermocouples are placed strategically so that the more rapidly heated areas are not permitted to exceed the prescribed temperature.

Cold rolling is a delicate operation requiring great skill. The extension of rimming steel sheets of drawing quality is generally from 0.6 to 1.3 per cent. Aluminum killed steel may be cold rolled as little as 0.2 per cent. The nature of the product being so subject to fluting before being skin rolled, requires care in handling from the lift or reel to the mill. The mill must be shaped to suit the shape of the annealed product, otherwise irregular yield and flow will result in defective "breaks."

An inspector of cold rolled sheets must necessarily discern those visible factors which detract from the usefulness of the product.

Pipe or central lamination may not be visible to the mill inspector. Deformation will disclose this discontinuity of section. The origin of this defect is oxidation of a central ingot void, such oxidation preventing welding in rolling.

Ridges or ghost lines are peculiar defects which an inspector can only see through deformation of the sheet. Ridges frequently have an underlying hard constituent which causes unequal flow, the resulting deformation showing up as a ridge in tension or a valley in compression. We have to look to the steelmakers for the elimination of this defect.

Scabs are caused by splash in pouring the ingot and may present a surface defect if not removed by scarfing from the slab.

Slivers are the result of rolling any surface irregularity into a superficial layer impressed into the surface of the sheet. A scab may be extended into a sliver. Slivers are generally lineal in character. Ruptures in the surface of the slab, if not cleaned out by scarfing, will show up in the finished sheet as slivers, not necessarily lineal.

Skin lamination is the result of entrapment of nonmetallic material just under the skin of the ingot such that successive rolling operations thin out the external layer into a skin so thin that it is prone to rupture when rolled or drawn.

Rolled-in-scale pits or pattern are visible in the form of isolated pits somewhat elongated or clusters of pits, or chevron in character either single or multiple. High pressure sprays operating at 1000 psi pressure are employed to remove scale from the partially hot rolled product. Any scale adhering to the surface causes uneven flow of metal at the roll contact.

Rolled over scratches may have their origin in the hot mill, on the hot mill run-out table or in the pickling line, including coiling after pickling.

Pits occur whenever any extraneous matter comes between the surface of the product and any roll which exerts sufficient pressure to cause an impression. Sources of pits are scale, welder flash, broken edges or surface defects from which particles detach themselves, or dirt from above or below, or the previous operation. These defects are most prevalent at coil ends.

Sticker breaks result when adjacent layers stick or weld together at one spot and may be torn apart. Breaks from too sharp bending usually result.

Handling breaks occur in sheets as a result of too sharp bending of the dead soft sheet as it is fed into the cold mill. Inclined tables and skillful feeders make it possible to eliminate this defect.

Pinchers and spreaders are breaks which result from either improper shape being fed into the cold rolls or rolling on improperly shaped mills.

Discoloration is generally caused by improper sealing of the annealing cover, but may also result from improper enveloping gas (DX gas) in which too much oxygen or carbon dioxide is present. Discoloration may also result from improper pickling or incomplete scrubbing after pickling.

Dimensions are checked many times in the course of processing cold rolled sheets. An inspector makes a final check before shipment, of gage, width, and in the case of cut lengths, both the cold roller and inspector make a final check.

Mechanical properties are studied by sampling the finished product and testing for hardness, generally by Rockwell B scale, ductility by Olsen cupping, yield strength and tensile strength by pulling apart measured cross section parallel edged specimens under measured loads, and measuring the elongation and the yield point elongation as an indication of stretcher straining. In the case of aluminum killed, we tensile test at room temperature and 420 F and compare the properties as a measure of stability.

Metallographic structure is studied microscopically at 100 magnifications and higher as required to determine grain size, structure and cleanliness.

With most careful workmanship many sources of defects are not completely eliminated. In fact, any slight deviation from perfect workmanship in steelmaking, heating, rolling, scarfing, annealing or handling takes its toll in rejects which vary generally between 3 and 15 per cent. Fortunately many defects, though visible, are so light in character as to be corrected by metal finishing. A reasonable amount of such work is part of the contract since sheets are seldom sold as primes only and coils never.

"STRESS CORROSION IN STAINLESS STEEL"

By R. A. LINCOLN

Chief Metallurgist

Allegheny Ludlum Steel Corp.

Brackenridge, Pa.

▲FEW metals or alloys are immune to stress corrosion. Brass season cracks. Tough steel boiler plate can crack

in service without apparent ductility, and is said to be suffering from caustic embrittlement. Commercial production and use of some aluminum alloys require control of susceptibility to stress corrosion. Expensive failures of stainless steel equipment have been traced to it.

In stainless steel, the term stress corrosion is often used in a highly restricted sense and refers only to relatively small part of the influence of stress on corrosion. This restricted usage refers to localized transcrystalline cracking and is often found to occur in corrosive conditions which produce either relatively mild general corrosion or no corrosion at all in the absence of stress. There are instances of stress corrosion cracking where the evidence of general corrosion is absent to such an extent that one might even question whether corrosion was actually involved in the failure. All records of stress corrosion cracking in service indicate that it is associated with tensile stresses acting at the surface. These may be residual stresses produced during manufacture, and the magnitude of these stresses necessary to produce failure is dependent upon service conditions such as temperature and concentration of the corrosive media. The author is not aware of any reported cases of stress corrosion where compressive stresses were the principal surface stresses.

The length of time necessary for stress corrosion cracks to form varies widely. For example, a glucose solution took 14 years to produce stress corrosion cracks in stainless steel, while a boiling concentrated aqueous solution of magnesium chloride will produce stress corrosion cracks in a few hours.

In discussing the general theory of stress corrosion, two conditions are necessary. There must exist in the metal a susceptibility to selective corrosion along continuous paths, and there must exist a condition of high stress acting in a direction tending to pull the metal apart along these continuous paths.

"STRESS CORROSION IN HIGH TENSILE WIRE"

By W. O. EVERLING

Director of Research

American Steel and Wire Div.

United States Steel Corp.

Cleveland, Ohio

▲THIS investigation has to do with the use of high carbon wire, with tensile strengths of approximately 200,000 psi and over, as a structural material working constantly at stresses in excess of 100,000 psi, particularly in pre-stressed concrete. In pre-stressed concrete —as in the case of its older sister, reinforced concrete— steel is intended to supply the necessary tensile strength while the concrete serves a dual function; namely, to absorb compression stresses and to protect the steel against corrosion.

Since its birth in the 1920's there must have been built at least 1000 linear structures, ranging from factory buildings to bridges with free span lengths up to 300 ft. To date, no single failure has been reported amongst any of these structures, regardless of cause. Certainly, there has been no evidence of stress corrosion.

In the field of circular structures, we have knowledge of literally thousands of miles of pre-stressed concrete pipelines operating at relatively high pressures. Some of these lines have now been in use for nearly 20 years, and not a single failure has so far been reported on any of these older lines. However, in two of the more recently built lines of this type, failures were reported within approximately a year of their construction. Both lines involved the use of oil tempered wire instead of the previously used hard drawn wire, and an examination of their failures showed unmistakable evidence of stress corrosion. A third failure of even more recent origin happened so soon after construction that some of the pipes could not even be placed into the ground. Again, the failure appeared to have been due to embrittling corrosion; this time, however, involving the use of hard drawn wire.

We started our investigation immediately after the failure involving oil tempered wire, to determine whether or not there is a significant difference between the susceptibility of oil tempered wire and hard drawn wire. Such a difference could perhaps be suggested by their different response to hydrogen embrittlement. Also included in our investigation were the possible effects of initial surface corrosion, as well as mechanically produced differences in surface conditions. Finally, we added a chloride solution to simulate the effect of marine exposure.

The results of this investigation are summarized as follows:

1. Within the limits of this investigation, high strength steel wire used as a construction material appears to be subject to stress corrosion failure only in the presence of nitrate solutions.
2. In nitrate solution, oil tempered wire has been proven to be substantially more sensitive to stress corrosion than wire in the hard drawn state.
3. Since all high strength steel wire used in prestressed concrete must be protected adequately against any type of corrosion, it follows that stress corrosion failure may be expected only in cases where such general protection breaks down.

"OLD CHALLENGES IN STEEL'S PUBLIC RELATIONS"

By EDWARD L. RYERSON

Chairman, Executive Committee

Inland Steel Co.

Chicago, Ill.

▲THE vast majority of American people, including steelworkers, seek the same things that management does, economically, socially, politically and in world

affairs. If the steel industry makes this clear, it will win increasing public support.

The final test as to the effectiveness of any public relations program remains with the individual companies and their own management philosophy. The public attitude concerning the steel industry is determined by their contacts with individual companies in their own communities.

We are on trial today with a government leadership that has pledged itself to maintain a sound and free economy. The need of our help to guarantee its continued existence is another reason for our enthusiastic support of a joint cooperative effort to maintain a favorable public opinion.

The public relations of the steel industry are vastly improved over what they were.

The industry was built with long and arduous hours of hard labor in advance of the development of modern mechanized operation. In the minds of many, this idea of the industry still prevails in spite of the fact that under existing conditions perhaps 95 per cent of all operations are completely mechanized and labor has advanced to such a high degree of skill that its principal function is control by management of machines—calling for brain in place of muscle.

The program that the industry carried on over the entire period of years from 1946 to the present has created a different viewpoint in the public's mind about the steel industry, and to a considerable degree about all private industry.

"EXCERPTS FROM AN ADDRESS"

By MAX D. HOWELL

Executive Vice President

American Iron and Steel Institute

New York, N. Y.

▲IN recent months, the general economic situation in this country has been of foremost interest everywhere and the statistics of the Institute have been in great demand by people who wanted to draw their conclusions about the facts of the iron and steel industry.

The adjustment from a war and semi-war economy to moderately lower production levels had long been expected by most thoughtful people. Sooner or later it was inevitable that the industrial economy, if it is to be the healthy, free economy which has made this country great, would have to get along without the artificial stimulus which the government had been administering for many years. Unfortunately, many of our economic advisers seem to have forgotten that every crop is not a bumper crop and that there have been lean years and fat years since the recorded history of man began.

When the decline first started, some writers and economists made much of the drop in the steel industry's operating rate, without acknowledging that more steel can be made at 75 per cent of present capacity than at 90 per cent a few years ago.

On January 1, 1954, the Institute released annual steel capacity figures of 124,330,410 tons—an increase over the previous year's capacity of 6,782,940 tons or nearly six per cent. This increase was largely the result of the completion of expansion programs started in 1950-1951, some of which were initiated at that time at the request of the government in order to provide reserve facilities which would be available in time of emergency.

This increased capacity, coupled with a decline in the requirements for the defense program, created an unrealistic decline in the weekly operating rate for the industry. In order to provide a more accurate presentation of the actual production of steel on a weekly basis, the Institute started the issuance of a new index of ingot production. This index relates the output of the steel industry to the production of previous normal peacetime years, the period 1947-1949 equaling 100.

Before the new index was announced, many people relied heavily upon the weekly steel operating rate as an economic indicator without realizing its limitations. They did not seem to realize that capacity operations in steel today produce a far greater tonnage than capacity operations a few years ago.

There has been no intention on our part to deprive people of the weekly steel operating rate. It has its uses. It is composed of two variables. The first variable is current production, which changes from week to week. The second is the annual capacity, which is computed once a year. The operating rate is a true index of production only in the year in which a given capacity is effective. It is, however, useful for showing the percentage of utilization of existing steel facilities and the reserve capacity available. We believe that people will intelligently utilize both the operating rate and the index when they understand their proper application to the steel industry's problems.

At one time, about 18 years ago, the industry had been accused of having too much capacity. A few years later it was suggested that there was not enough capacity. Still later, in 1950, another enlargement of capacity was begun, about the time that the shooting started in Korea and not long after the government indicated a need for reserve capacity. Now it seems that capacity has a wide margin over current consumption. The reserve margin was over 31,000,000 tons, based on operations during the early part of this year. This reserve capacity is being maintained because the industry is mindful of the government's possible future defense needs. It is immediately available to meet an emergency, if and when it comes.

In the first five months of this year the steel industry of the United States will have produced about 36,700,000 net tons of raw steel. That is close to six per cent higher than the average during 1947 to 1949. It is interesting to note that this amount of steel in five months is only 12 per cent less than Russia is believed to have made in all of last year.

The steel industry's employment is still high. Well over 600,000 people are being employed in iron and steel production. Wages are at the highest levels ever attained. There have been six wage rate increases in the postwar years. When allowance is made for the increases in retail prices, "real" hourly earnings of steel-

workers were up 34 per cent in January of this year as compared to 1939.

Business is not bad when this basic industry's production, employment, and wages are as high as at present.

Today—the iron and steel industry is better equipped, better managed, and more efficient than at any time in its history. The American public ought never to lose sight of the fact that this country has the world's strongest steel industry—an industry that will continue to be one of the strong foundations for the industrial economy of our country, and an industry that has demonstrated its ability and willingness to provide the facilities and products as they are needed to meet the requirements of our ever expanding economy.

"THE NEXT HEAT OF STEEL"

By CLIFFORD F. HOOD

President

United States Steel Corp.

Pittsburgh, Pa.

▲A fabulous new era for the American steel industry can be opened only if the profit system wins its present war for survival. The steel industry may be only in its infancy in the United States, judging from the possibilities seen by research and technology. In the past seven years alone, more than 33,000,000 tons of steelmaking capacity have been added to our facilities—more than was ever added in any like period.

New sources and vast quantities of iron ore have been located and are being developed. The practical stage in mining and processing taconite has been reached. The industry is producing better steels and better products of steel.

The biggest news of all is the fact that $5,500,000,000 has been spent in achieving these gains.

Research and technology are setting the stage now for steels of the future.

Who knows when electricity developed in atomic power plants will make possible the reduction of iron ore by using hydrogen as the reducing agent rather than carbon?

Who knows when automation will make possible greater efficiency in almost every step of the steelmaking procedure?

Who knows when the miracles of electronics will give us control of unbelievable accuracy and the ultimate in quality production of steels of still unheard of potentialities?

Among present objectives in research to improve steel, are the following:

Higher strength without sacrificing ductility.

Improved toughness of steel at low temperatures.

Greater resistance to corrosion both in ordinary atmospheres and in special environments.

Improved formability, weldability and other special service characteristics.

To realize these goals, steelmen must prove themselves experts not merely as metallurgists but as "mentallurgists." They must prove finally that private enterprise can meet the challenges before it. They must speak for themselves, they have allowed others to speak for them too often in matters vital to the successful performance of their jobs.

Affirmative action is necessary in employee relations. The employer is the natural leader of his employees and always will be despite academic beliefs and doctrinaire teachings to the contrary.

Employee attitudes are vital. In any competitive industry, that company will be most successful which takes positive action to instill in the minds of its employees such elements as self-reliance, optimism, interest and a high regard for their respective responsibilities.

Local, state and national action is advocated to help win the battle of the century for private capitalism.

This situation will be changed if management begins to call the hands of those who gamble with our economic and personal freedoms.

"IMPORTANCE OF THE STEEL INDUSTRY"

By ERNEST T. WEIR

Chairman

National Steel Corp.

Pittsburgh, Pa.

▲ THE steel industry is an essential part of the foundation—the substructure—on which our entire economy is based. There is no substitute for its production. The industry must be prepared to supply whatever requirement may exist for its products currently. In addition, it must always be prepared to cover unpredictable increases in those requirements—up to and including the demands of national emergencies. This state of preparedness must include not only the provision and maintenance of facilities for the making of sufficient raw steel and facilities for finishing that steel into the full range of products but also must provide complete assurance of a continuing supply of sufficient raw materials.

This obligation of the steel industry to be constantly prepared is in the nature of a public trust. Management in the steel industry has so regarded it and has acted accordingly. There has never been a time when American progress has been held back because this industry was short-sighted or over-cautious in its provision of sufficient raw materials, plants and facilities to meet the steel requirements of the country. The entire history of the industry has been one of continuous expansion which, in most cases, has fully anticipated future needs.

The only real steel shortage in my experience was the one that developed after the war . . . which was certainly a highly abnormal condition. And in view of the

inventory situations of many steel consumers today there is a reasonable question that the shortage was ever quite as serious as it may have seemed during that period.

The steel industry is important in another way that is not generally recognized. That is the contribution which the industry has made to the improvement of manufacturing methods and to end products of all sorts. Naturally, the buying public is interested in the final product. Usually, it does not see the steel in the product nor, beyond that, what steel has done to make the product possible.

As we know, it has been the constant and successful aim of the industry to develop better and more versatile steel at the lowest possible cost. It is because of this, for instance, that the number of types of steel available to the automotive industry has increased from 11 in 1910 to 162 distinct types of steel in more than 1000 variations today.

The steel industry recognizes its obligations to employees. Its wage rates rank among the highest in all industry, as do its provisions for retirement, insurance and other employee benefits. No industry can claim a longer, more consistent or more successful program to improve safety and working conditions. Every effort is made to sustain employment on as steady a basis as possible.

The steel industry recognizes its obligation to communities. Steel companies live as good citizens in the cities and towns in which they are represented. They actively support and participate in all worthwhile community undertakings.

In all of these respects the steel industry—and that really means its management—has conducted itself with an understanding and dependability that is appropriate to the basic importance of the industry. But there is one relationship—an extremely vital one—in which this industry has not perceived and met its obligation. That is the relationship of the steel industry to the investing public.

The history of steel has never been good from an investment standpoint. The financial community and the investing public have always regarded the steel industry with doubt and misgiving as an investment. Consequently, we have paid a penalty. Steel securities have not been in demand. They have not sold at a fair market value. And they do not today even though they stand at levels somewhat higher than usual.

I do not know of any other industry which is required to have so much investment behind each unit of production as the steel industry. At present costs, the capital represented by the raw material reserves and the plant and facilities needed to produce a ton of steel in ingot form amounts to a minimum of $250.

Last Thursday (May 19, 1954), taking the market price of the securities of the 10 largest steel companies in the hands of the public—common stock, preferred stock and bonds — would indicate that the average value placed by the public on each ton of steelmaking capacity in those companies was $53.02. That is roughly 20 per cent of what it would cost—on a most conservative basis—to replace that ton of capacity.

Now why should an industry which is indispensable and as stable as the Rock of Gibraltar from a physical standpoint be considered as a risk, a speculation from a financial standpoint? Why does the steel industry compare so unfavorably in this respect with most other major industries? Why are we in the big league as technical operators and in the minor league as financial operators? The answer, of course, is that in the past the record of the steel industry as to earnings and the payment of dividends has been uncertain and sporadic.

The National City Bank of New York has made a continuing study of earnings in manufacturing industries. The measure used in the study is earnings as a percentage of net worth.

In the 26-year period from 1928 through 1953 the earnings of the steel industry were below the average for all manufacturing industry *in every single year*. In five years of this 26-year period the steel industry had a net loss. The average of all industry showed a loss figure in only one year—1932. The study included 43 industries in the first six years of the period and 45 industries in the remaining 20 years—all of the important manufacturing industries in the country. In 1942, the steel industry was at absolute bottom in this group of industries. The highest it ever climbed to was 21st place from the top last year. In 13 of the 26 years, the steel industry never rose above sixth place *from the bottom*. What a record!

This record shows conclusively that the old title of this industry—"Prince or Pauper"—is highly inaccurate. We have been "paupers" often enough. But where do you find the "prince"? Not in a single year. In comparison with manufacturing industry as a whole we certainly have never earned profits nor paid dividends that could be described as "princely." And on the basis of this record, we can hardly blame the investor for having taken a dim view of our industry.

Who or what should we blame? Can we blame conditions? And say that the steel industry has fundamental problems that are much more difficult than the problems of most other industries. But other industries do have their serious problems and while ours may be somewhat more difficult they are not a good reason for the steel industry to be under average—to lag behind most other industries all the time. No, in our search for the reason for the poor earnings and poor dividends record I think that we should first take a good, long look at ourselves—the management of the companies in this industry.

I am sure it is not news to you that others are now looking at us—and with a coldly appraising eye. They are the people who have responsibility for the investment of funds and the people who have responsibility for advising the public on investments. They want to know if at long last we have learned anything from experience—if steel management now recognizes that an industry so essential as steel has an obligation to make fair earnings and pay fair dividends—not just in some years but on a dependable, regular basis.

The steel industry is now in a period of trial. Steel management must demonstrate that it does recognize this obligation and also that it has the ability to carry

it out. It *must* do this because in the years immediately ahead the steel industry will be confronted with financial requirements heavier than anything in previous experience. If the steel industry is to cover those requirements—and also remain a *private* industry—it will have to obtain a large part of the money it needs from the investing public.

Let us consider the situation we face.

The steel industry today has a steelmaking capacity in excess of 124,000,000 tons. We know from experience that this capacity will have to be replaced entirely within a period of about 30 years. I can see no indication that costs are going to be any lower than they are now. On that basis—and most conservatively estimated—a minimum of $30,000,000,000 will be required just to replace the plants and facilities that comprise the present steel industry. In other words, it must be our job to find an average of $1,000,000,000 per year for this purpose . . . or about $400,000,000 more per year than the industry provided for depreciation and depletion in 1953.

In addition to replacement, we will be confronted with the need to finance the expansion of steelmaking capacity. In view of the huge expansion in recent years and in view of the present operating rate, we may feel that extensive new construction should not be a problem for some time to come. But, of course, it is an absolute certainty we will be increasing capacity again and probably not too far in the future. In the United States and in the world, population is steadily increasing and, in addition, the per capita consumption of steel is likewise steadily increasing. I will not hazard a guess as to what year will find that 124,000,000 tons of ingot steel are not enough, but when it comes the steel industry must be ready for it.

Future expansion involves another problem—both physical and financial—that we must begin to meet now. That is the eternal problem of finding raw materials—principally iron ore and coal. To an increasing extent this is becoming more difficult and more expensive. We can no longer depend on reserves near our operations. We must go farther and farther afield and, consequently, must pay higher costs for location, development and transportation.

Raw materials impose a very heavy financial burden. The investment in them is very large and it represents capital locked up in the ground which can be recovered only over a long period of years. This is one of the unusual problems to which I referred. Responsibility for raw materials is an essential difference between our industry and fabricating industries. Our finished product is the fabricator's raw material. He needs to have on hand only an inventory in proportion to his current production. But we must find and maintain the raw materials to cover maximum demand not only in the near future but in the very remote future.

When we add all of these factors together, we can come to only one conclusion. The steel industry is going to need money and lots of it. The big question is where do we get it? Naturally, some of the money for both replacement and expansion must come from earnings. This, in itself, indicates the need for larger earnings on a steady basis. But it is obvious that the total capital requirements of the steel industry simply cannot come out of earnings. There must be a large and continuing influx of new money and there is one source —and only one—to which we can look for it. That source is investment by the public through the purchase of steel company bonds and equities.

Of course, this investment will not be forthcoming unless and until the public is assured that the steel industry has both the intention and the ability to make fair earnings and pay fair dividends on a continuing basis. This means a very definite change in the investment public's opinion of the industry. It is the obligation of management in the steel industry—the management of every steel company—to bring that change about.

We know precisely the nature of our main difficulty. The steel industry is highly vulnerable to cyclical swings. No matter how great a decline may occur in the demand for steel, this industry must still carry the raw materials and facilities for 100 per cent operations. This is our obligation to steel consumers and to the country.

The cost of this obligation must be shared by the consumers of steel. Its burden should not fall exclusively on investors in the steel industry—which is a fact that steel management has overlooked in the past. The true cost of producing steel includes the cost of providing and maintaining *all* steel facilities not just the *part* of those facilities that may be needed when steel requirements are below the capacity of the industry.

In the past, as I say, this true cost of production has not been adequately recognized by steel management. The cost of steel to consuming industries has not included this service factor of having the supply of steel available when and as it is needed. Nothing shows this more clearly than the comparison of the earnings of the steel industry with the earnings of other industries —all of which are more or less dependent on steel.

What we now must get into our minds as steel management is that these other industries are competitors—competitors for the favor of the investment public. We have to deliver a competitive product. In this case the product is comprised of earnings and dividends that compare in all respects with those of other industries in our class. And that means the most important industries of this country. We know that if our physical product—our steel—is not competitive in quality, service and price we cannot hope to interest customers. In the same way, on the financial side, if our earnings and dividends are not comparable to those of other industries we cannot hope to interest the investors.

Now at this point there is something that I want to make very clear. What I have said might be interpreted to mean that I am advocating that the investor be given a "break" at the expense of employees and the public. Nothing can be farther from the truth. Every building and facility in American industry today is there because investors put it there.

In the private economy the investor who provides the machine is just as necessary as the employee who operates the machine. The investor renders an essential service to industry; he is fully entitled to fair compensa-

tion for that service. Our whole American experience proves that the interests of investors and employees and public are mutual, not opposed. Where investors find the best opportunity for a good return, employees also find the best opportunity for good and improving jobs and wages . . . and the public finds the best and lowest cost products.

In many respects the steel industry has a record of which it may be proud. Its treatment of the investor has been an unfortunate exception. The investor has been the forgotten man of our industry. He must not be any longer.

I cannot over-emphasize the fact that it is the obligation of management—the management of every company—to establish the steel industry as one that merits the confidence of the investor in every respect . . . because a favorable investment attitude is absolutely essential to the future of our industry. We can develop investor confidence only by showing, now and in the future, that we—the management in the steel industry—will fully recognize the importance of the investor; that we will regard protection of the investor's interest as a definite management responsibility, and that it is our firm intention to carry out this responsibility by maintaining a clear record of fair earnings and fair dividends on a dependable basis. I urge, as strongly as I can, that from now on, proper consideration of the investor will be the policy of the steel industry.

TABLE I

Comparison of Net Earnings — Iron and Steel and Other Manufacturing Industries 1928 Through 1953

(Percentage of net profit to net worth)

Year	Highest industry	Average all industries	Iron and steel	Lowest industry	Number of industries with higher earnings than the iron and steel industry	Number of industries with lower earnings than the iron and steel industry
1928	27.7	11.6	7.0	—1.2	30	11
1929	27.1	12.8	11.2	—5.6	25	17
1930	23.6	6.4	4.5	—7.2	23	19
1931	18.0	2.3	—0.5	—10.0	24	18
1932	13.4	—0.5	—4.0	—10.4	30	12
1933	12.3	2.5	—1.9	—4.0	38	4
1934	21.7	4.3	—0.4	—7.2	41	3
1935	21.5	6.7	1.3	2.8	39	5
1936	25.7	10.4	4.7	3.7	40	4
1937	38.5	10.8	6.9	—0.9	35	9
1938	36.6	4.8	—0.2	—9.5	39	5
1939	37.5	8.5	4.5	2.2	39	5
1940	33.9	10.3	8.5	4.6	31	13
1941	48.8	12.4	9.6	5.7	39	5
1942	45.0	10.1	6.5	6.5	44	0
1943	36.8	9.9	5.6	4.0	42	2
1944	23.6	9.8	5.2	1.8	43	1
1945	22.2	9.3	5.1	2.6	43	1
1946	41.6	12.1	7.4	4.8	40	4
1947	34.8	17.1	11.3	—6.0	41	3
1948	31.5	18.9	14.0	3.1	35	9
1949	30.2	13.9	11.6	3.0	25	19
1950	32.3	17.1	15.3	—1.8	26	18
1951	19.9	14.4	12.3	4.7	25	19
1952	18.7	12.3	8.8	—3.5	33	11
1953	21.0	12.5	11.6	—4.6	20	24

Source: Study by the National City Bank of New York.

"THE IMPACT OF ECONOMIC TRENDS ON THE STEEL INDUSTRY"

By MARTIN R. GAINSBRUGH
Chief Economist
National Industrial Conference Board
Washington, D. C.

▲ THE steel industry is now faced with a new challenge—the challenge of utilizing its new and potent capacity and an evolving technology to serve the needs of the nation at peace.

In our manufacturing economy, one in every eight jobs is created directly in the iron and steel industry. A somewhat larger percentage of all incomes paid out by manufacturing industries is generated through iron and steel production.

In 1952, average hourly earnings of production workers (in blast furnaces, steel works, and rolling mills) have risen from $1.99 to $2.14 (March 1954), straight time hourly earnings from $1.94 to $2.11, and average weekly earnings have held around $79.50, despite a sharp drop in average weekly hours (40.0 to 37.1). During this time there has been marked stability in the cost of living. (The Consumers' Price Index stood at 113.5 in 1952, 114.6 in April 1954.) Matched against steel workers, who gained 15 cents in average hourly earnings, and 17 cents in straight time earnings, automobile workers received 9 cents and 10 cents, respectively.

Since the war, 10 per cent of manufacturing investment in new plant and equipment has been for the expansion or improvement of iron and steel capacity. In a world divided into hostile camps, our numbers count but little, while 124,000,000 tons of ingot capacity—about half of the world's total—symbolizes the industrial potential that is a deterent to aggression.

In a recent analysis of the inter-industry flow of goods and services, the iron and steel industry appeared as a significant purchaser for 74 of the 199 industries (not only of primary metals, petroleum and structural clay products, but of electric power and railroad services); it appeared as a major seller to 135 of the 199 industries. Furthermore, the industry is now putting its products directly into the house and the household, he said, thus becoming a consumer product as well as an industrial product.

The three dimensions of the iron and steel industry—the employment and incomes it creates, the investment it undertakes and the central position it occupies both as a market for the output of other industries and as a supplier of material and products to other industries—are a dramatic indication of its central importance of the national economy.

Adding up the plus and minus signs, the conclusion that emerges is one of economic activity tapering off at somewhere around current levels. The cyclical correction which began almost a year ago seems to be at or near its final stages. However, the general pattern that currently prevails—and is likely to continue for the remainder of this year and well into 1955—is of strong sustaining forces, rather than a preponderance of either expansionary or contracting factors.

Modernization of Skelp Mill at Wheeling Steel's Benwood Works

By S. W. CRISMAN
Field Engineer
Elliott Co.
Pittsburgh, Pa.

. . . . typical of the ingenuity of the steel producer is the way in which he has modified his existing equipment to obtain more production . . . .

▲ THE Benwood, W. Va., plant of the Wheeling Steel Corp. produces butt weld pipe by the Fretz Moon process with modern high speed mills. Due to advancements in the art, higher mill speeds and mill improvements, the capacity of the pipe mills became greater than the supply of skelp, and the problem of "what to do" required a practical answer.

It was realized that any improvements to the existing skelp mill had to be made with a minimum of down time on production. It was also realized that the improvements should result in better heating of slabs at lower costs in addition to the increased production. These decisions involved:

1. An increase of slab thickness from 3 to 4¾ in.
2. Additional stands on the skelp mill for reducing the heavier slabs to skelp sizes.
3. An increase in mill speeds and billet heating capacity.

When approaching a problem such as above, a major consideration is the amount of expenditures that can be justified for the improvements based on increased capacity, better product and reduction in operating costs.

The capacity of a mill is usually controlled by two factors, (1) the tonnage that can be heated in the furnace, and (2) the capacity of the mill to roll product.

The maximum heating capacity of the old furnace was 60 tons per hour. The location and size of a new furnace were limited by the space requirements of the proposed roughing mill additions and the mill area available in this location. The mill layout incorporating these conditions indicated that a modern furnace capable of heating slabs up to 4¾ in. thick and with a capacity of 80 tons per hour could be installed and this rating furnace was planned.

This increase in slab thickness with the same length of slab, would result in heavier slabs, which in turn would produce longer lengths of skelp. These longer lengths would mean less crop ends per ton of production, hence, an increase of yield.

For example, if we assume that only two feet of skelp is cropped from each end of the piece, with normal production from the furnace, there would be some 1200 less pieces to crop on the new mill per week when compared with normal furnace production using the old slab sizes. In a year this saving would amount to many tons of product that would be worth considerably more per ton as skelp than as crop scrap. In addition, there would be a saving in production costs on the pipe mills with some 600 less end welds to make each week and a similar number of pipe lengths which would contain the end welds.

Having established the furnace capacity and the slab sizes, the rolling practice on the mill had to be analyzed.

The old mill was well designed with ten horizontal, 2-high, roll stands and four vertical edging mills. The first two stands of the old mill are driven by 1 — 500 hp, d-c motor. The next four horizontal stands are driven by 1 — 2000-hp, d-c motor. On the next four stands, each unit of two stands is driven by one 2000-hp, d-c motor. In normal rolling the speed cones on the mill were good and the motor loads well distributed in conformance with the motor ratings.

With the increased slab thickness and added furnace capacity, means had to be provided to reduce the additional slab thickness by means of more roughing stands so that the new slabs entering the original No. 1 stand would have approximately the same thickness as the old slab sizes entering this stand, and also maintain the same width. The solution to this problem was the addi-

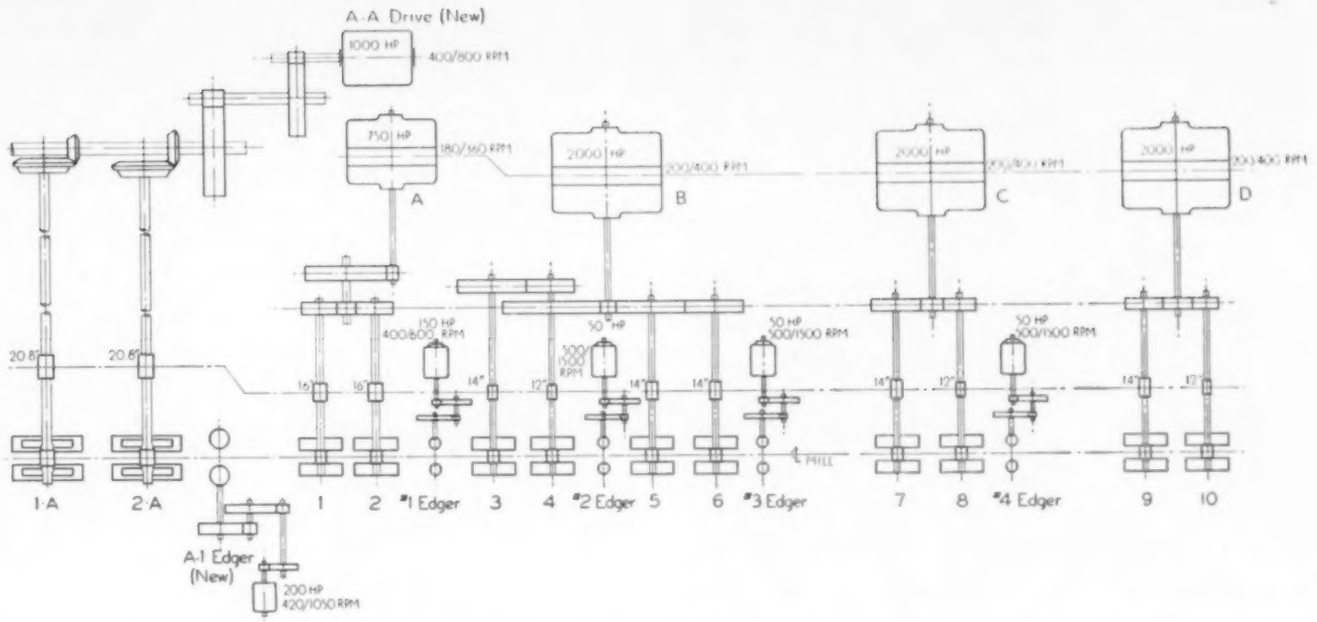


Figure 1 — Two additional stands were added to the mill shown in this sketch as No. 1-A and 2-A.

TABLE I
Skelp Mill Data

Stand	Motors		Gear ratio	Roll diameter, in.	Roll rpm	Roll face speed, fpm	
	Hp	Rpm				Min	Max
No. 1 A Rougher	1000	400/800	0.0156	16.25/18	6.24/13.26	26.4	62.2
No. 2 A Rougher	.....	.....	0.0215	16.00/17.75	8.6/18.28	36.0	85.0
No. 1 A Edger	200	420/1050	0.009	25.5/34	3.78/9.45	25.24	84.00
No. 1 Rougher	750	180/360	0.0592	13.0/14.5	10.656/21.312	36.27	81.00
No. 2 Rougher	.....	.....	0.0818	12.75/13.75	14.724/29.448	49.49	106.01
No. 1 Edger	150	400/600	0.0334	15.0/22.5	13.36/20.04	52.46	118.06
No. 3 Rougher	2000	200/400	0.1193	12/13	23.86/47.72	74.96	162.41
No. 4 Rougher	.....	.....	0.171	12.25/13.25	34.2/68.4	109.68	237.27
No. 2 Edger	50	500/1500	0.0834	11.75/16.75	41.7/125.1	128.27	548.56
No. 5 Finisher	.....	.....	0.2391	12.5/13.5	47.82/95.64	156.49	338.02
No. 6 Finisher	.....	.....	0.2820	13.5/14.5	56.40/112.80	199.33	428.20
No. 3 Edger	50	500/500	0.0982	12.75/17.25	49.1/147.3	163.85	665.2
No. 7 Finisher	2000	200/400	0.4059	13.25/14.25	81.188/162.876	281.61	605.83
No. 8 Finisher	.....	.....	0.5942	13.0/14.0	118.84/237.68	404.46	871.14
No. 4 Edger	50	500/1500	0.1359	12.0/18.0	67.95/203.85	226.82	927.27
No. 9 Finisher	2000	200/400	0.8472	12.5/13.75	169.44/338.88	554.49	1219.90
No. 10 Finisher	.....	.....	1.22	12.0/13.25	244./488	766.55	1692.82

tion of two roughing stands and one vertical stand. The layout for this new mill is shown in Figure 1.

Having determined the mill layout, various mill schedules had to be analyzed to find the load distribution on the various main drive motors and the resultant speeds for the different stands. It was obvious that the top speed of No. 10 stand had to be increased, with corresponding increases in the other stands. The top finishing speed of the mill was increased from 1162 to 1692 fpm and the entering speed on the No. 1-A stand was set at 26.1 fpm low speed to 60.8 fpm maximum. This latter in conjunction with the pass reduction schedule determined the size of the new motor to drive new 1-A and 2-A stands, which was 1000 hp at 400/800 rpm. See Figure 2.

Figure 2 — A 1000-hp, 400/800-rpm motor was selected to drive the two new stands.

The study further showed that with slab reductions per pass according to schedules, the motor loads were distributed so that they were within capacity ratings and the existing supporting motor-generator sets could carry the increased loading.

It was possible to design the 1000-hp drive for No. 1-A and 2-A stands so that the new motor could be installed in the existing motor room, thus saving the cost of a new building. This drive is shown in Figure 3.

Figure 3 — The additional motor was installed in the existing motor room.

Figure 4 shows the speed cones for both the old mill and the new mill. The maximum finishing speed of No. 10 stand was increased about 45 per cent with the speeds of other stands raised to get the smooth speed cones shown. These speed changes were obtained by installing new gears which job was done without loss of production in the mill.

With the foregoing speeds and rolling schedules established, it is possible to examine the operation of the mill as a unit.

Based on the ability of the new furnace to heat 80 tons of slab per hour, this would result in about 66 — 2500 lb slabs about 30 ft-0 in. long and 5¾ in. wide available for rolling each hour. The top speed of the new stand 1-A is 62 fpm or 1.04 fps. With a 4-in. spacing between slabs, these slabs would be rolled in 29 seconds in this stand. Hence if operated at top speed, the first roughing stand could roll 124 slabs per hour, whereas the furnace could heat only 66 such slabs.

If we make a further check on the last finishing stand we find it has a top speed of 1692 fpm. Assuming the coil is 1300 ft long leaving No. 10 stand and a 20 per cent reduction is made in this stand, the entering length would be 1040 ft. With a roll face speed of 1692 fpm, or 28.2 fps, the piece would be in the rolls 37 seconds. Hence, if the pass could be kept full, 97 pieces could be rolled each hour.

The above indicates that the mill, with normal operations, can roll all the steel the furnace can heat with a comfortable margin for the usual mill adjustments and delays.

The new equipment for this mill has been installed, mill changes made and mill operation started on January 6, 1953. The major problem in the project was the construction of the new heating furnace with a minimum of interference with production. This was done by constructing the new furnace in an area close to the new permanent location on a temporary foundation in which heavy track rails were imbedded. It was supported on 132 anti-friction roller bearing rollers. Furnace

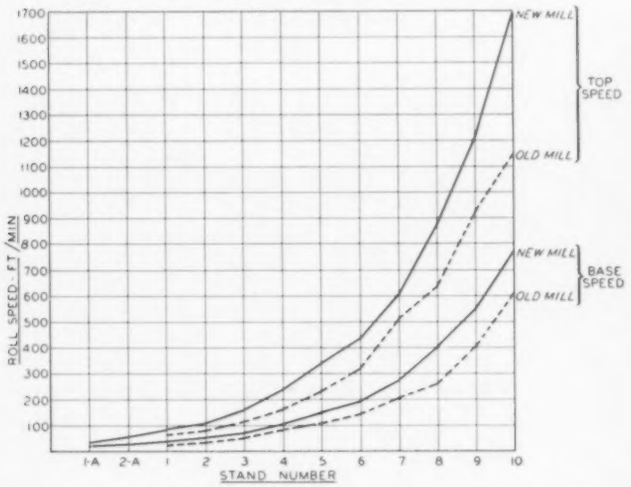


Figure 4 — Speed cones for old and new mills show increase in speed obtained by addition of two new stands.

auxiliaries and mill additions were installed or partially assembled as space and mill operations would permit. The old mill was shut down at 11:00 pm December 20, 1952. The permanent foundation for the new furnace was completed on December 27, 1952, and the new furnace rolled into position with hydraulic jacks.

Work then proceeded on the piping connections to recuperator and combustion equipment, the billet charger, pushing machinery, billet ejector, pinch rolls, waste gas piping, etc.

A small temporary furnace 5 ft wide and 30 ft long was installed to bridge the space between the furnace push-out door and the first stand of the old mill, in order that production could proceed while the foundations for the new stands were being completed.

Slabs heated to 2100 F started passing from the new furnace, through the small furnace and to the old mill at 7:00 am January 6, 1953, after 16⅓ days of construction. The new stands and gearing changes were then completed during mill operations.

This installation is an example of effective modern engineering and planning between mill operators, engineers and equipment builders wherein an important production unit obtained an increase in capacity with minimum loss of product at a reasonable cost.

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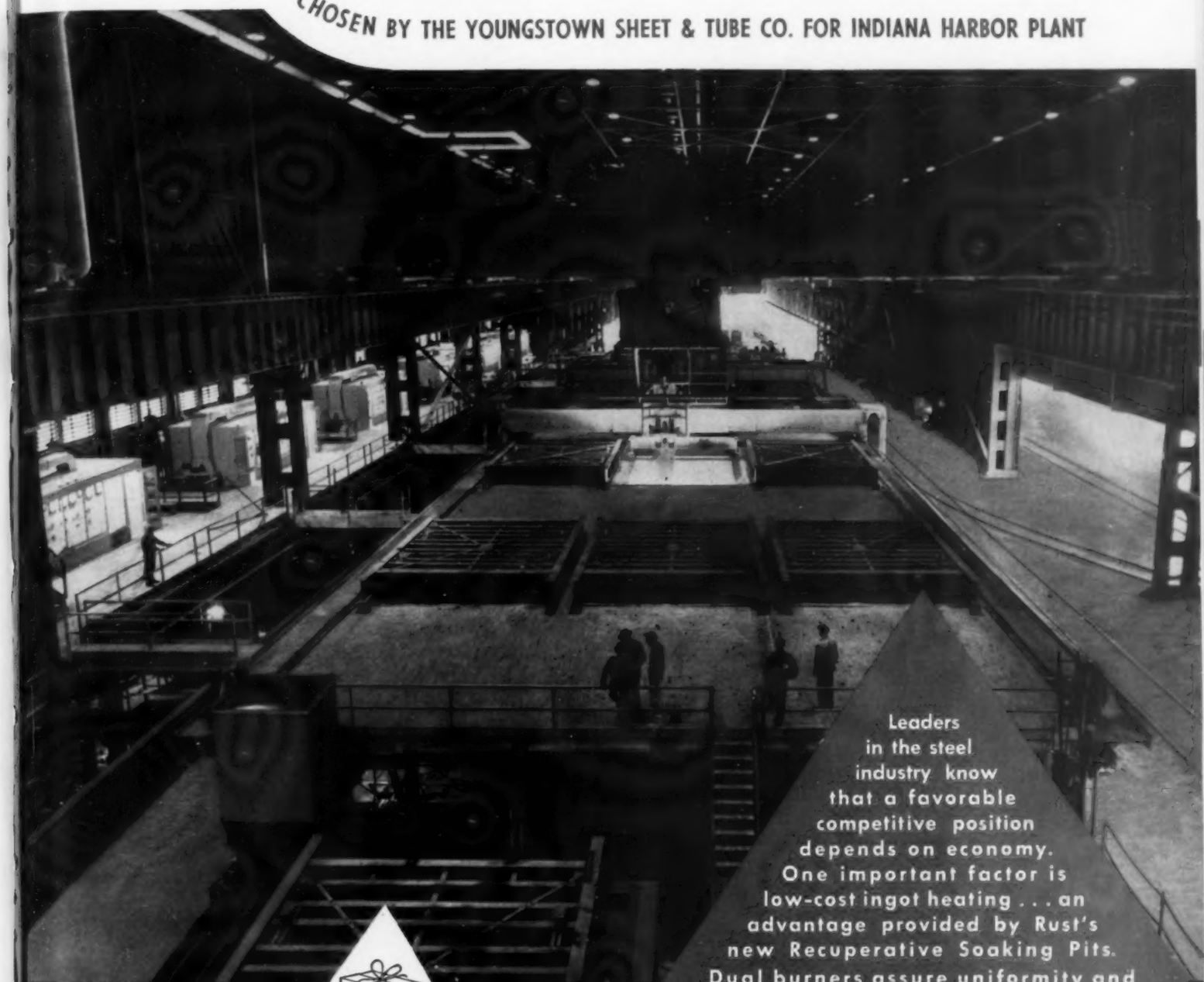

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When a melt is poured, an ordinary mold expands away from the roll surface. The roll, in chilling, further widens the gap.

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BLAW-KNOX COMPANY / ROLLS DIVISION
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THE ELECTRIC INGOT PROCESS

▲ UNLIKE the conventional process of steel casting, the electric ingot process, owned by the M. W. Kellogg Co., subsidiary of Pullman Inc., gives continuous melting and casting.

One of the basic raw materials in this process is strip supplied in coils. For the iron-base alloys, this strip usually is plain low-carbon rimmed steel. For nonferrous alloys and alloys containing a very small percentage of iron, strip is made of some appropriate material such as nickel. This strip usually is obtained in the cold-rolled condition in a gage and width suitable for forming into the desired size of electrode.

As indicated, the strip is passed through the tube-forming machine K (Figure 1) where it is formed into a cylindrical electrode G with edges butted. After leaving the tube-forming machine, the tubular electrode is passed through contact shoe H where it picks up the current used for melting. After passing the contact shoe, it extends into the mold, where the current discharge F takes place below the slag blanket C. The location of the current discharge below the bottom of the contact shoe H is maintained at substantially a constant distance throughout the melting process.

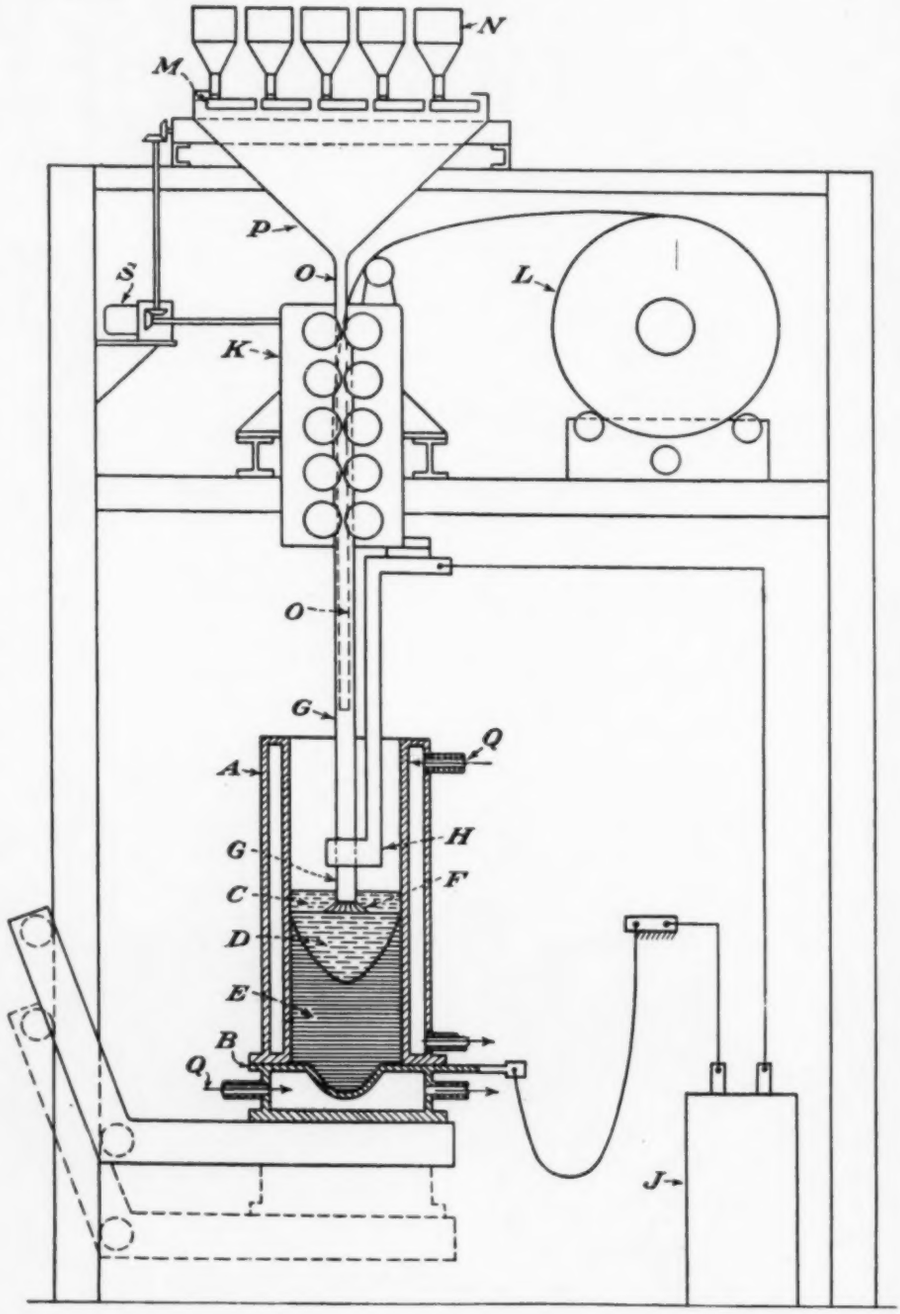
When one coil is nearly consumed it is welded to a new coil while melting is in progress.

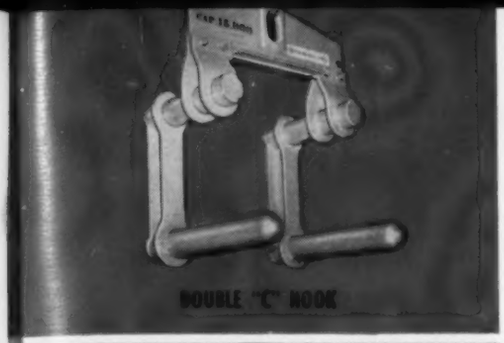
The melting process is initiated by supplying a small quantity of crushed alloying materials, mixed in the proportion of the alloy to be melted, to the center of stool B. The mold and stool assembly is then raised until the end of electrode G contacts the pile of alloying materials. A suitable supply of dry synthetic flux is added to the mold to cover the entire stool and material in it. The contractor is closed and the tube-forming machine is started. It is only a matter of seconds until the flux blanket is liquified and the alloy-making process is under way.

As the level of the alloy rises in the mold, the mold is retracted from the machine, and this continues until the desired length of ingot has been made.

Since strip L is almost pure iron, it

Figure 1 — Diagram shows operation of machine for making alloys by the electric ingot process.





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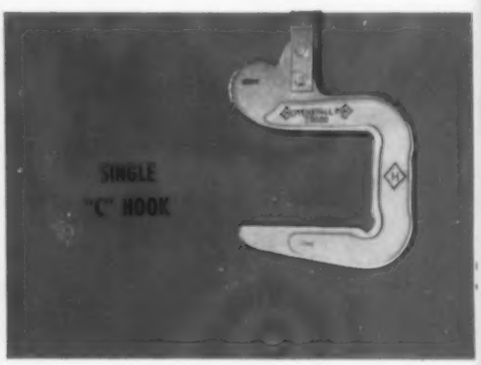

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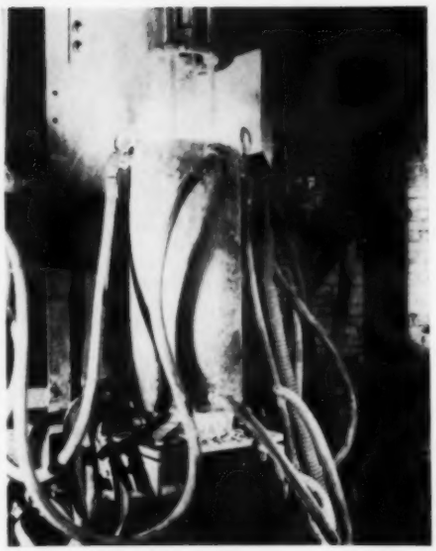


Figure 2 — In the electric ingot process, when the ingot is made, the mold is swung aside and another swung in for minimum loss of time.

is necessary to add alloy materials to the melt to produce the grade of steel desired. The addition of these elements is accomplished by metering each one through a separate metering device M. The metering devices M are driven by the same motor that drives the tube-forming machine; in this way the rate of alloy addition is synchronized with the rate of electrode consumption.

The alloying materials are obtained in a free-flowing crushed condition and stored in hoppers N. These alloying materials are collected in hopper P and conducted through the tube-forming machine and into the center of electrode G through conduit O. These materials fall freely from the metering device to the current discharge in the mold but, since they are released only at the proportionate rate for the production of the alloy intended, there is no chance of a discrepancy occurring because of this free-falling action.

The size of electrode G and the maximum rate at which the alloying materials are fed through it are controlled in such a way that it is impossible for the alloying materials to build up in the electrode if the end becomes plugged. This is accomplished by making certain that the internal volume of electrode G displaced per unit of time is greater than the total volume of all alloying materials added.

Not only is this process free from refractory linings, but, owing to the fast solidification resulting from the use of the water-cooled mold coupled with the relatively slow melting rate, progressive solidification is obtained. The metal freezes at the rate it is added. This does not mean that it freezes instantly, however, because there is a delay of a few minutes between the time of fusion of a part of the metal and the solidification of this same part. This time delay is a function of a depth of the bath D. Once this depth has been established in the early stages of the procedure, it does not change, regardless of the length of the ingot. There is a definite balance between the rate of heat input and heat removal. This is one of the most important features of the process.

Figure 3 — Automatic metering device controls flow of granulated alloying materials into the electric ingot machine. Materials are stored in bins.

The superheated bath of molten metal D, which is contained in what might be considered a crucible of solidified metal of the same analysis, provides the most ideal feeding mechanism imaginable for feeding the volume change that is constantly taking place as the metal solidifies. In addition to this feeding mechanism, the presence of this same molten bath has a distinct stress-relieving effect on the solidified metal, with the result that residual stresses in the ingots are a great deal lower than those in ingots cast in the normal way.

The combination of these two features helps to produce ingots entirely free from either primary or secondary pipe, internal bursts, or segregated materials, either metallic or non-metallic.

The raw materials used in the manufacture of these ingots are literally injected, in solid form, below the surface of a molten blanket of flux, where they are liquified and put into thorough solution and then progressively solidified without ever having been exposed to the atmosphere. Because of this characteristic, the melting losses are very low, virtually all elements showing a yield of 100 per cent.

This process is highly flexible in that the grade of steel melted can be changed at will simply by changing the adjustment of the metering device. There is nothing to fear in going direct from a heat of chrome-nickel steel to one of high-speed steel, for instance, because there are no refractories in the melting chamber to contaminate one heat with elements that may have been picked up from the previous heat.

This process is also flexible inasmuch as it is not only simple to change the size of the ingot being cast, but its length can be changed at will within a given standard-length mold. Since there is never more than a small amount of liquid metal in the mold at any one time, ingots of any desired length may be made without fear of producing unsound centers. In view of this, it is possible to melt small heats of special alloys for test purposes under the same conditions that would be used for production. In other words, if the physical tests from a test heat show good results, it is not necessary to translate the melting technique used on the test heat into another technique to be used for production, as is required with conventional melting-furnace practice. In this process, the production and test techniques are identical, as are the products.

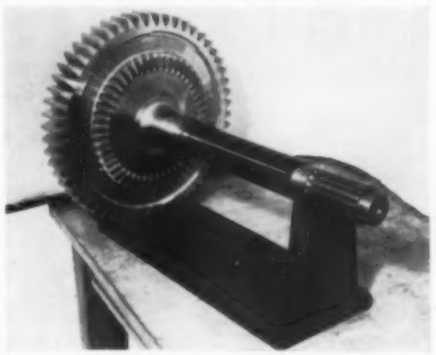
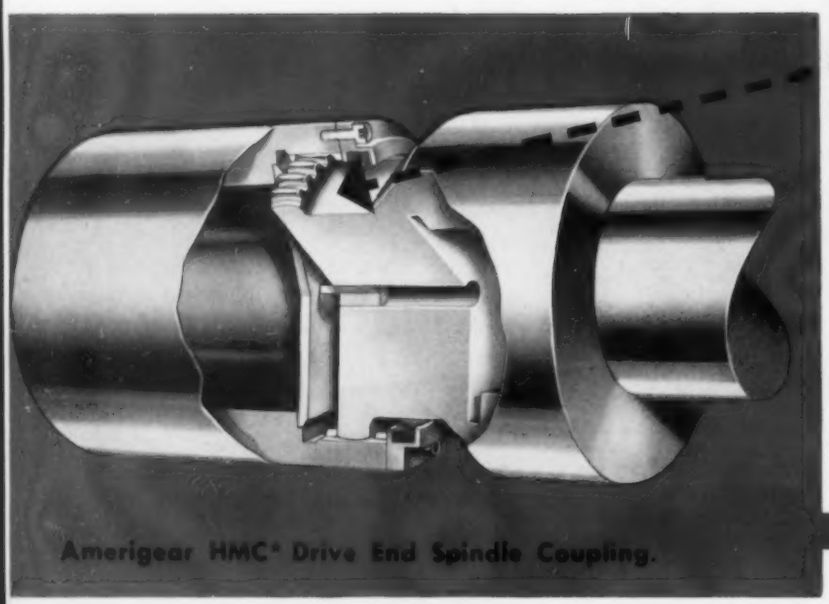
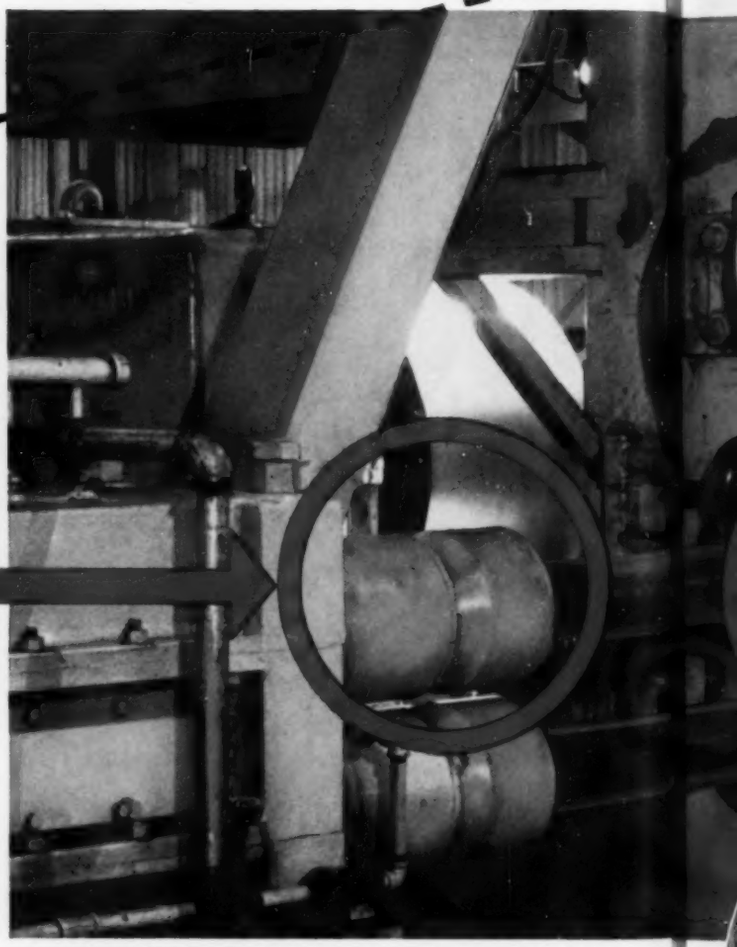


Figure 4 — Practically all jet engines being produced today use solid turbine wheels with super alloys produced by the electric ingot process.

SPINDLE DRIVES Between Rolls and Pinions Obtain Optimum Operating Efficiency With *Amerigear*® High Misalignment Capacity* Gear-Type Couplings Having Patented Tooth Form Teeth



Amerigear HMC* Drive End Spindle Coupling.



Four-Hi Bliss Reversing Cold Reduction Mill equipped with roll drive spindle couplings; operating at 125 h.p. to 750 h.p., 91 to 250 r.p.m.

AMERIGEAR High Misalignment Capacity Gear-Type Couplings operate at much higher speeds, require less space, and greatly *reduce the maintenance cycle* over that of conventional type spindle roll drives. The torque load is carried on flanks of Patented Tooth Forms rather than on tooth ends. In Amerigear HMC* Couplings the engaging roll end coupling teeth are specifically modified *for quick assembly and disassembly, thus greatly reducing down time for roll changes.*

Patented Tooth Forms incorporated in Amerigear HMC* Couplings are produced from various types of steels, heat treated and hardened, depending upon operating conditions.

Amerigear Engineers are available to assist in *engineering special applications* and for adapting Amerigear Standard Type Couplings to solve your power transmission problems. Write for Catalog 501 and Bulletin 1052, or attach coupon to your business letterhead.

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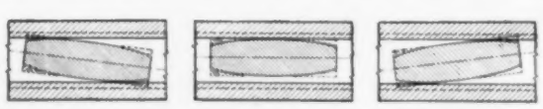
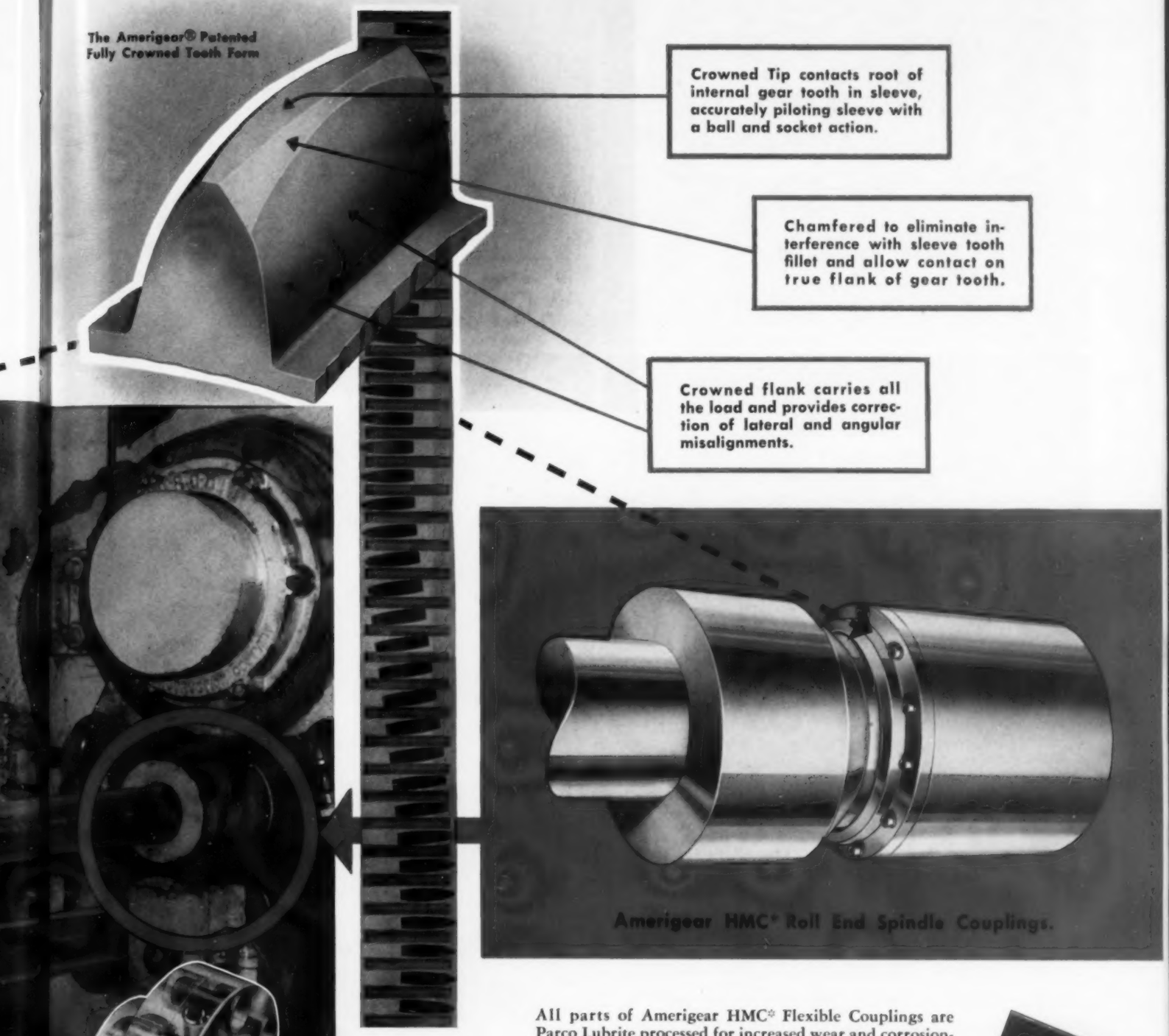
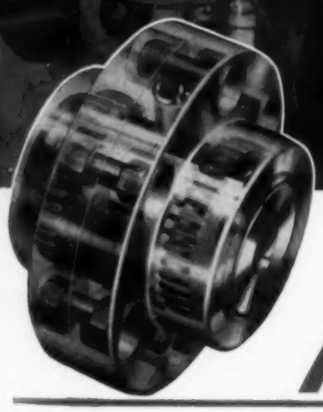


Comparison with gearing of conventional gear-type couplings shows how the Patented Amerigear Tooth Form eliminates *tooth end loading* and simultaneously allows for higher misalignment capacity for both lateral and angular misalignment. Dotted lines indicate gear teeth of conventional gear couplings.


The Amerigear® Patented Fully Crowned Tooth Form
Crowned Tip contacts root of internal gear tooth in sleeve, accurately piloting sleeve with a ball and socket action.
Chamfered to eliminate interference with sleeve tooth fillet and allow contact on true flank of gear tooth.
Crowned flank carries all the load and provides correction of lateral and angular misalignments.

Amerigear HMC* Roll End Spindle Couplings.



Illustrating Full Cycle Misalignment Pattern of Amerigear H.M.C.* Patented Tooth Form.

All parts of Amerigear HMC* Flexible Couplings are Parco Lubrite processed for increased wear and corrosion-resistance. The assembled coupling is essentially a dust and moisture-proof unit due to positive hub oil seals. The oil seal assures continuous operation for years with the original lubricant.

Amerigear®

HMC* FLEXIBLE COUPLING

One of several Standard Types embodying the Patented Amerigear Tooth Form
Patented and Patents Pending

AMERICAN FLEXIBLE COUPLING COMPANY

ZURN

Originator of the famous Amerigear Patented Tooth Form
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SALES OFFICES IN PRINCIPAL CITIES OF THE WORLD

In Canada: Canadian Zurn Engineering Ltd., 2052 St. Catherine St., W., Montreal 25, P.Q.

AMERICAN FLEXIBLE COUPLING COMPANY
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Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name ..... *Title* .....

Company .....

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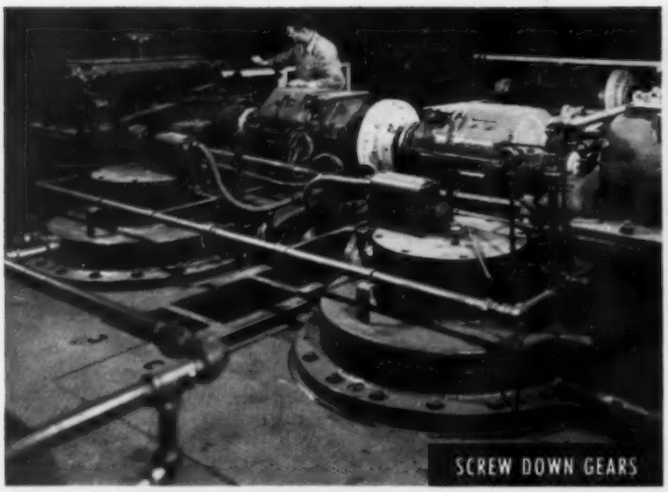

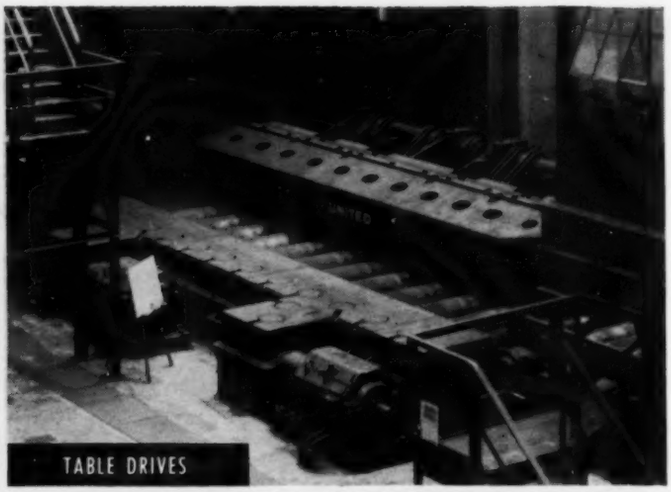

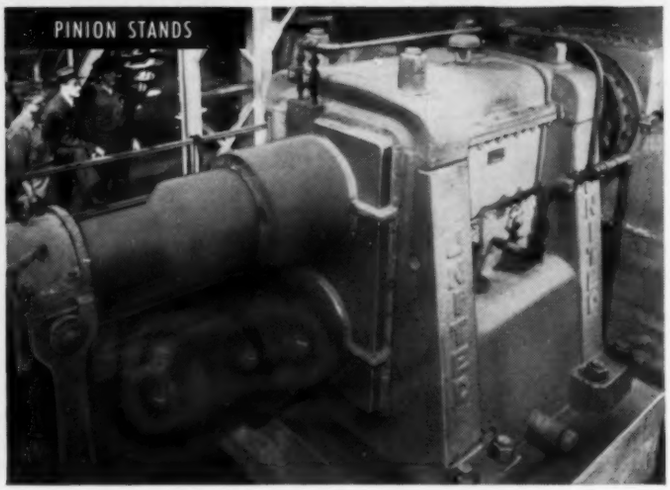

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Japanese Steel Stages Comeback

. . . . few would have thought when the war was over that Japanese steel would ever get back to the scale of operations in progress today . . . .

By STEPHEN BADLAM
Engineer
Lewis Machinery Div.
Blaw-Knox Co.
Pittsburgh, Pa.

▲ THE iron and steel industry of Japan is of comparatively recent, but rapid growth, from a negligible amount of 184,000 net tons of finished steel products produced in 1910, to about 5,551,000 net tons of finished steel products at the time of Japan's entry into World War II in 1941. At that time the country had an integrated steelmaking capacity of the order of 8,349,000 net tons of ingots per year from which was produced a wide range of products, plates, sheets and strip, bars and wire rods, structural shapes, rails and pipe. The production of Japan, in 1941, was exceeded only by that of the United States, Germany, Great Britain, and Russia.

Included in the Japanese flat steel rolling capacity were the following noteworthy installations, all of which were built and placed in operation in the years 1936 to 1941:

One 210-in., 4-high reversing plate mill with 30,000-hp steam engine drive. This was the widest existing plate mill, being slightly wider than the 208-in. Lukens mill in the United States and considerably wider than the largest European mill (about 180-in.).

One 86-in., 4-high semi-continuous plate mill comprising a broadside stand, a vertical edger, a single-stand, 4-high reversing rougher, and a four-stand, 4-high continuous finisher. Since the war this mill has been equipped with two additional finishing stands, and hot coilers for the production of strip.

One 43-in., 4-high continuous hot strip mill comprising those 2-high and one 4-high roughing stands, three vertical edgers, and a six-stand, 4-high continuous finishing train.

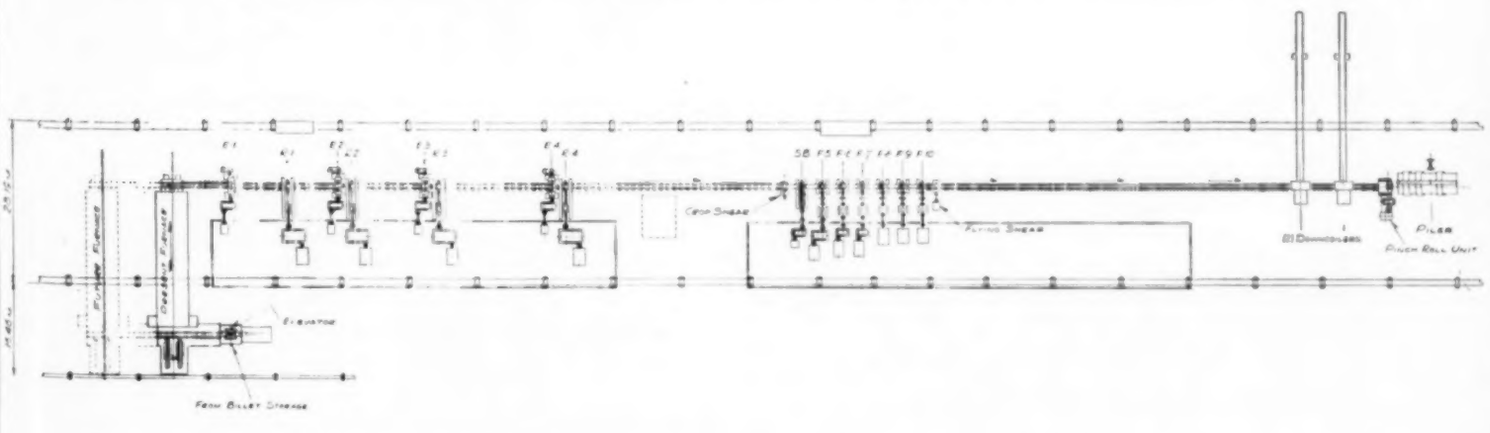
Supplementing the hot strip mills there were also installed a considerable number of cold mills for the production of cold reduced sheets, and strip for tinning. Included in the number were two five-stand, 4-high tandem mills of what, at the time, were the most modern designs. In addition there were a number of single stand mills, both of the reversing type for strip and of the non-reversing type for sheet length material.

There were also a number of temper pass mills of the single-stand type and of the two-stand tandem type.

Peak production in Japan was attained in the second year after Pearl Harbor, when 9,676,000 net tons of steel ingots and castings were produced. From this time on, and up to the time of the Japanese surrender, the almost complete interruption of sea-borne transportation, as well as continued bombing of the Japanese homeland, caused the eventual loss of approximately 90 per cent of the steel-producing capacity, and the production for the later war years and for several years following was reduced to an insignificant figure—for example, to about 608,000 net tons of steel ingots and castings in 1946.

Since that time a rehabilitation program has been in progress and an annual capacity of 8,418,000 net tons of steel ingots and castings was reached in 1953. It is expected that by the end of 1954 steel production will approach the all-time high set in 1943. Several new mills have been purchased, principally in the United States, as well as additions to existing mills

Figure 1 — Layout shows 28-in. continuous hot strip mill recently completed by Nichia Steel Co. at Kure, Japan.



and considerable auxiliary equipment.

An important part of the postwar rehabilitation of the Japanese steel industry is a 28-in. continuous hot strip mill recently completed by the Nichia Steel Co. on the site of the former naval base at Kure. This mill was designed and the greater part of the equipment built in the United States by the Lewis Machinery Division of the Blaw-Knox Co. Other parts of the mill equipment and the electrical equipment were built in Japan from Lewis designs and specifications.

The mill went into operation on August 8, 1953, and at the present time it is in full operation, rolling the entire range of products for which it was designed. The production of the

TABLE I

Unit		Roll size, in.			Distance from preceding unit, ft-in.	Motor				Gear ratio	Roll rpm	Roll surface speed, fpm
Stand No.	Type	Body length	Work roll diameter	Backup roll diameter		Hp	Voltage	Type	Rpm			
E-1	Vertical edger	7	22		35-3	250	230	d-c	350/700	22.75	15.4/30.8	88.7/177.4
R-1	2-High rougher	29	28		33-6	1500	3300	60-cycle	514	20.9	24.6	180
E-2	Vertical edger	7	22		30-6	250	230	d-c	350/700	22.75	15.4/30.8	88.7/177.4
R-2	2-High rougher	29	28		7-6	1500	3300	60-cycle	514	20.9	24.6	180
E-3	Vertical edger	7	22		43-9	150	230	d-c	400/1200	22.75	17.6/52.8	101.4/304.2
R-3	2-High rougher	29	28		7-6	1500	3300	60-cycle	514	15.6	33.0	242
E-4	Vertical edger	7	22		67-9	150	230	d-c	400/1200	22.75	17.6/52.8	101.4/304.2
R-4	2-High rougher	29	28		7-6	500	3300	60-cycle	514	12.7	40.5	296
	Crop shear				128-0	40	230	d-c	850	50.1	17	
SB	2-High scale breaker	29	18		10-0	250	600	d-c	350/875	19.4	18/45	85/211
F-5	4-High finisher	29	15	28	12-0	1500	600	d-c	400/1000	9.5	42/106	165/413
F-6	4-High finisher	29	15	28	12-0	1500	600	d-c	400/1000	5.83	68.4/171	269/673
F-7	4-High finisher	29	15	28	12-0	1500	600	d-c	400/1000	3.88	103/257	405/1012
F-8	4-High finisher	29	15	28	12-0	1500	600	d-c	150/375	Direct	150/375	570/1425
F-9	4-High finisher	29	15	28	12-0	1500	600	d-c	200/563	Direct	200/563	760/2139
F-10	4-High finisher	29	15	28	12-0	1500	600	d-c	200/563	Direct	200/563	760/2139
	Flying shear				10-4	600	600	d-c	0/300	Direct		
	Pinch roll				204-3¾	75	345	d-c	515/1300	2.0	257.5/650	808/2041
	Coiler mandrel				4-10¾	100	345	d-c	485/1200	4.25	183/366	1150/2300
	Wrapper rolls					4-15	345	d-c	0/725	Direct		
	Pinch roll				20-1¼	75	345	d-c	515/1300	2.0	257.5/650	808/2041
	Coiler mandrel				4-10¾	100	345	d-c	485/1200	4.25	183/366	1150/2300
	Wrapper rolls					4-15	345	d-c	0/725	Direct		
	Pinch roll				26-2	75	230	d-c	400/1600	2.36	169.5/677.9	710.5/2841.8
	Sheet piler				19-6	15	230	d-c	725	11.67		

TABLE II

Roller Tables

Table No.	Description	Rollers				Motors					
		Diam, in.	Length, in.	Spacing, in.	Fpm	No.	Hp	Rpm	Voltage	Cycles	Type
1	Furnace charging	12	29	30	300	14	3	95.4	220	60	Gear motor
2	Furnace discharge	12	29	30	300	17	3	95.4	220	60	Gear motor
3	No. 1 approach	12	29	29	189	11	2	60	220	60	Gear motor
4	No. 2 approach	12	29	31	189	10	2	60	220	60	Gear motor
5	No. 3 approach	12	29	45	189	10	2	60	220	60	Gear motor
6	No. 4 approach	12	29	46	246	16	2	78.5	220	60	Gear motor
7	Crop shear approach	12	29	48	80/320	30	½ to 2	25.5/102	Various	d-c	Gear motor
8	Flying shear approach	12	29	24	589/2356	2	½ to 2	18.7/750	Various	d-c	Gear motor
9	No. 1 hot coiler approach	12	29	24	589/2356	100	½ to 2	18.7/750	Various	d-c	Gear motor
10	No. 2 hot coiler approach	12	29	24	589/2356	6	½ to 2	18.7/750	Various	d-c	Gear motor
11	Sheet piler approach	12	29	24	589/2356	8	½ to 2	18.7/750	Various	d-c	Gear motor

All rollers are individually gear motor driven, Tables 1-6 inclusive a-c constant frequency, Tables 7-10, inclusive, d-c adjustable voltage

TABLE III

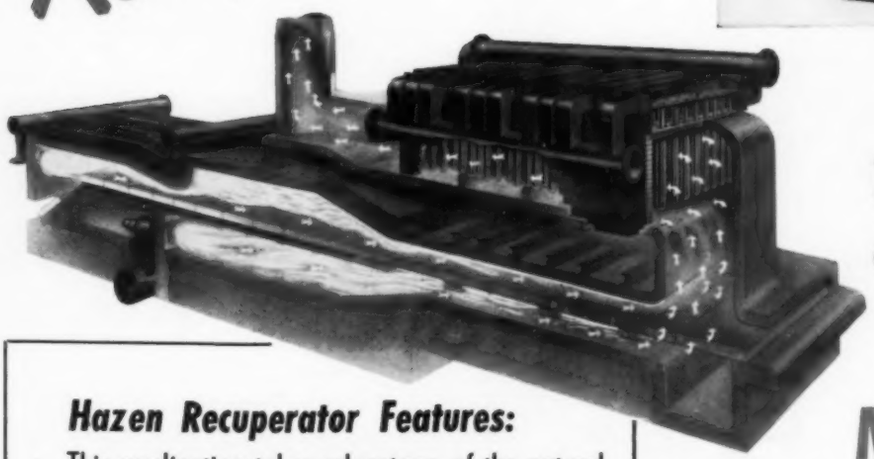
Constant voltage d-c auxiliaries

Description	No.	Hp	Rpm	Type	Voltage, d-c
Slab elevator screws	1	10	800	Mill	230
Vertical edger screw adjustment	4	15	725	Mill	230
Horizontal roll screw adjustment	8	10	800	Mill	230
Finishing scale breaker screw adjustment	2	7½	900	Mill	230
Finishing stand screw adjustment	12	10	800	Mill	230

All motors — mill type, 600 series, 230-volt d-c.

HAZEN FURNACE RECUPERATOR

the only 100% American Metallic Recuperator



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- Increased preheat . . . due to availability of a larger percentage of flue gases at higher temperatures.
- Economies in initial cost . . . by reducing the required amount of excavating and furnace foundation.
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- Greater accessibility for ease of cleaning.
- Walkways may be provided around the recuperator for convenience of inspection and cleaning.
- Recuperator, flue and stack may be supported from steel work independent of the furnace bindings.
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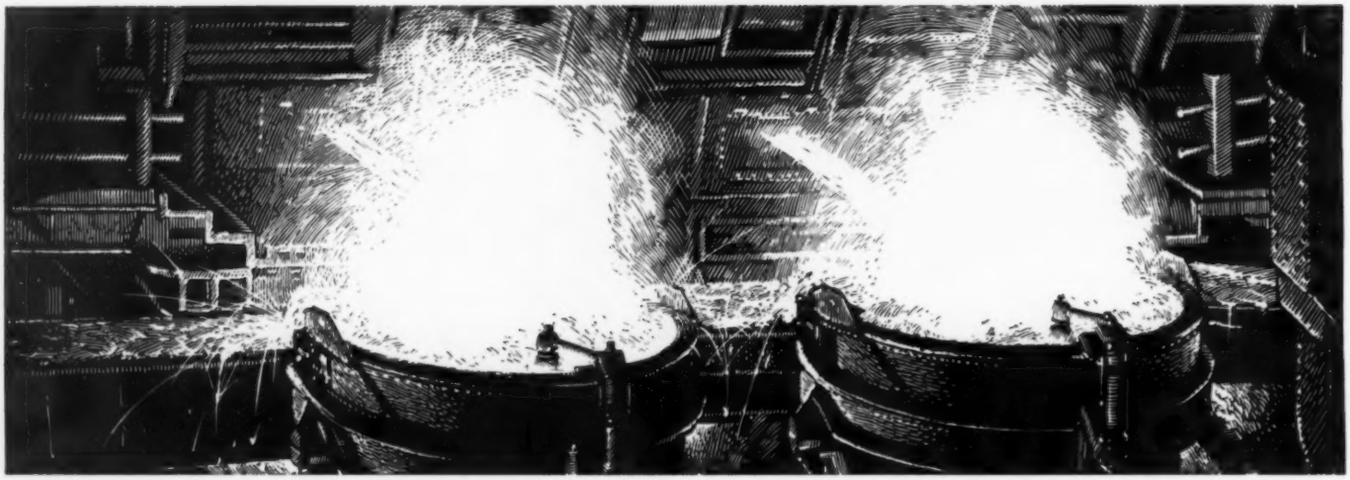

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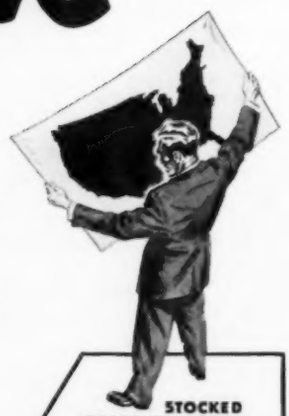
Plan now to avoid future "hot spot" failures and expensive down time — install Rockbestos A.V.C. wire and cable.



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mill, as presently constituted, with a single heating furnace, is approximately 38.5 net tons per hr, which may be doubled by the addition of a second furnace.

The mill is designed to produce hot rolled strip in widths from 10.7 in. to 23.6 in. in the usual range of gages from 0.050 in. to 0.250 in. At present it is producing 0.050 in. thick up to 15 in. wide, 0.060 in. thick up to 16 in. wide, 0.070 in. thick up to 18 in. wide, 0.085 in. thick up to 20 in. wide, and

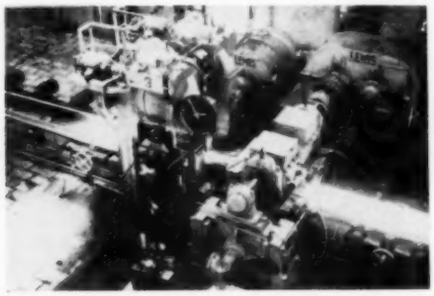


Figure 2 — No. 3 roughing stand is driven by a 1500-hp, 60-cycle, 514-rpm motor.

0.125 in. thick up to 23.6 in. wide. The strip goes into a wide range of products, ranging from automotive parts, building hardware, household utensils and cutlery, to tinplate for packing food products.

In respect to width of product, the Nichia mill fills an existing gap between the narrow strip mill (under 10 in.) and the wide range strip mills (43 to 80 in.) built prior to World War II.

The mill is designed along the same lines as the wider mills in the United States, but is scaled down in width to suit the particular range of sizes that was required.

The salient features of the mill are shown in Tables I, II and III and in the accompanying arrangement drawing.

Space has been provided between No. 1 vertical edger and No. 1 horizontal stand for an additional horizontal stand, should this be considered advisable in the future.

The buildings housing the hot strip mill consist of three parallel bays, the center bay of 85 ft-6 in. span covering the mill and the main drive motors.

The motors are enclosed with side walls and a lean-to roof under the main crane span, forming two motor rooms each about 40 ft wide. On the one side of the main span, there is the slab storage bay of 54-ft span and on the other side the coil storage of 85 ft-4 in. span. The charging end of the slab furnace projects into the slab storage building, and is provided with a screw-operated, motor-driven magazine slab elevator, upon which a 15 to 20-ton lift of slabs may be placed by the slab storage crane. The slabs are pushed off the slab elevator, singly, onto the furnace approach table by means of a hydraulic cylinder, and spotted in front of the furnace charging door. A double cylinder hydraulic slab pusher pushes the slabs into, and through, the furnace, and discharges the heated slabs onto the mill approach table.

The continuous slab heating furnace is of the horizontal hearth type, end-charge and end-discharge, and has a hearth 15 ft-6 in. wide x 70 ft long and rated heating capacity of 40 net tons per hour. The furnace is fuel-oil fired, two-zone, top and bottom fired, with tile recuperators. The furnace was designed by the Loftus Engineering Co. from Lewis specifications, and the critical items, such as burners, controls, and recuperator tile were shipped from the United States. Other parts, such as structural steel, plates, and fire brick, were made in Japan.

The furnace pushers are hydraulically operated by means of two 10 in. diameter x 16-in. stroke, 2500-psi cylinders, and can push either a single row of 12-ft slabs, or a double row of 6-ft slabs through the furnace. The furnace approach table, like all other roller tables in the mill, is individually motor driven.

The roughing train consists of one vertical edging stand, followed by a horizontal stand, and this in turn followed by three sets of vertical and horizontal stands spaced at varying distances to accommodate the elongation of the piece.

Following the fourth roughing stand, there is a connecting table 128 ft long leading to a crop shear and finishing scalebreaker, followed by a six-stand, 4-high, finishing train spaced on 12-ft centers. The crop shear is of the up-cut type and has capacity to cut 1-in. thick x 24-in. wide of hot steel.

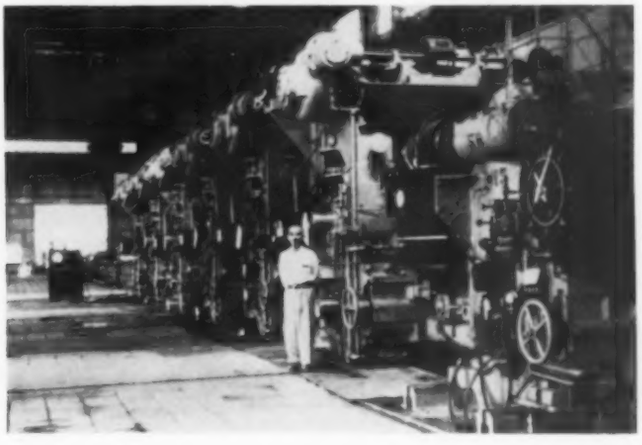
The finishing scalebreaker is a two-high stand and serves to break the scale, which is then completely removed by a hydraulic spray immediately prior to entry into the six-stand finishing train.

Between the finishing scalebreaker and the first finishing stand and between the following finishing stands are vertical up-loopers.

All roller tables consist of individually gear motor driven rollers. Up to No. 4 roughing stand gear motors are used with output speed of 95.4 rpm for the furnace approach and delivery tables, and from 60 to 78.5 rpm for the intermediate mill tables.

Figure 3 — General view of mill looks toward the finishing train.

Figure 4 — Finishing train consists of six 4-high stands.



Between No. 4 roughing stand and the finishing train, the motors are variable voltage with output speeds from 25.5 to 102 rpm. Between the finishing stand and the downcoilers and sheet piler, the motors are variable voltage output speed from 187.5 to 750 rpm.

Immediately following the last stand of the continuous finishing train is a rotary drum type flying shear capable of cutting lengths from 15 to 30 ft with one set of drums, or down to 10 ft with the use of a second set of drums, at speeds up to 2300 fpm. Following this is a 210-ft table provided with individually driven rollers leading to two mandrel type downcoilers with motor operated wrapper rolls for coiled material; following these are a pinch roll and sheet piler for lengths previously cut on the flying shear.

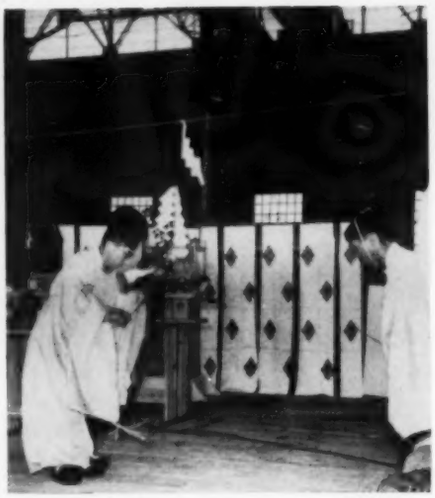


Figure 5 — Japanese consider mill opening so important that they have a religious ceremony at the dedication. Shinto priests are asking the blessing of the gods for successful plant operation and safety of the workers.

Between each vertical edger and the following horizontal stand, and also between the finishing scalebreak and the first finishing stand, both sides of the strip are blasted with water sprays at 1250 psi to remove scale.

Provision is made for cooling the strip as required, both between the last roughing stand and the finishing scalebreaker, and between the last finishing stand and the downcoilers. The strip is flooded with water during its passage over substantially the entire length of the tables. This effectively prevents any excessive grain growth due to finishing at a high temperature and subsequent slow cooling in coils, or in packs at the sheet piler.

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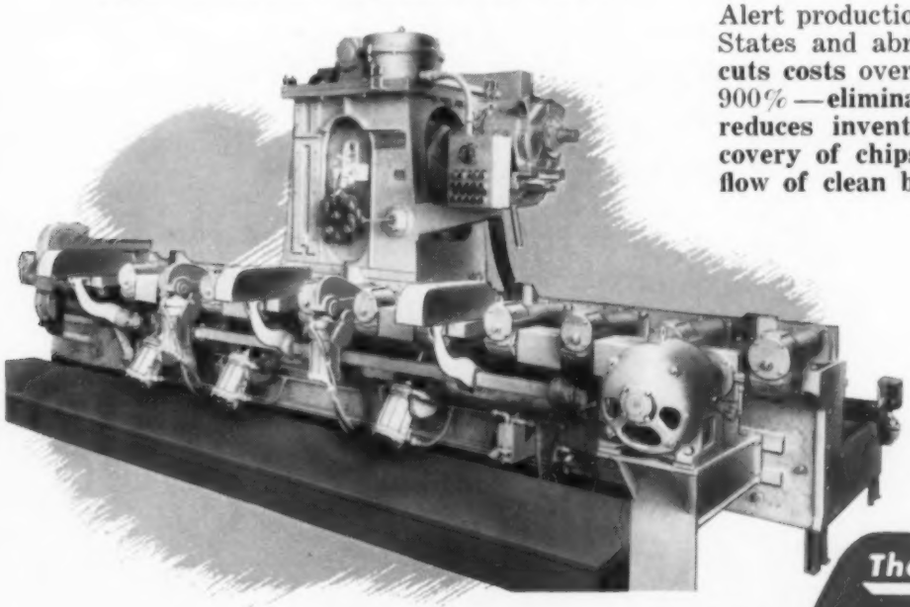

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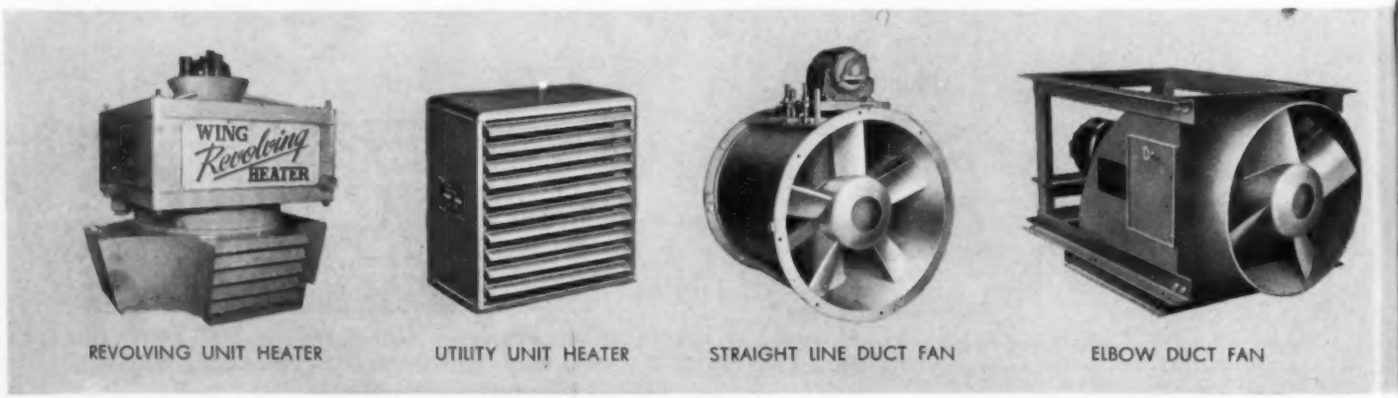

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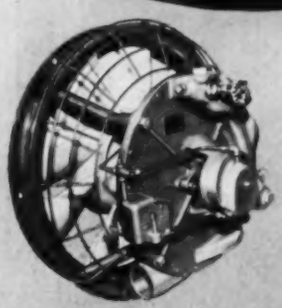
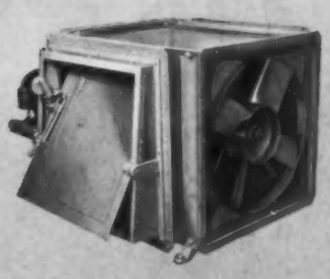


TURBINE BLOWER



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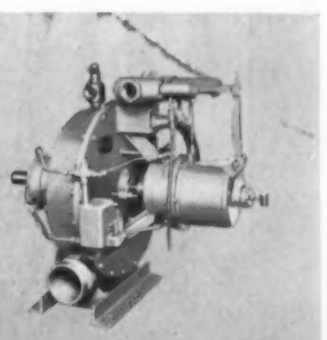

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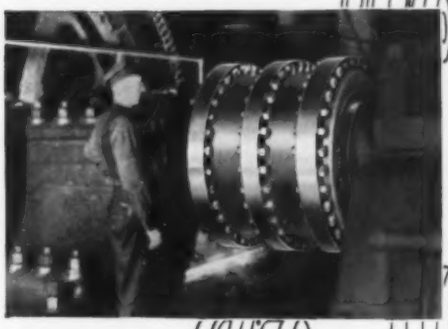
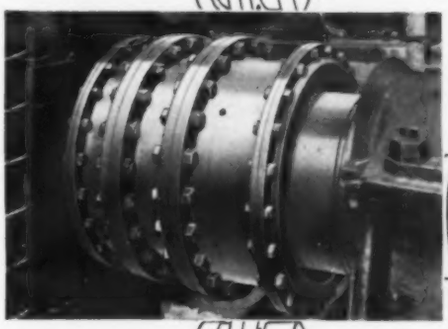
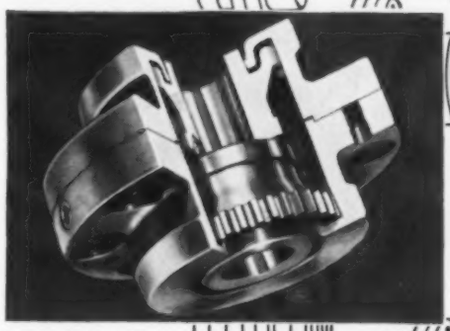


Fast's Coupling installation in a leading steel production plant.



Close-up of Fast's Coupling . . . proved ideal for heavy industry.



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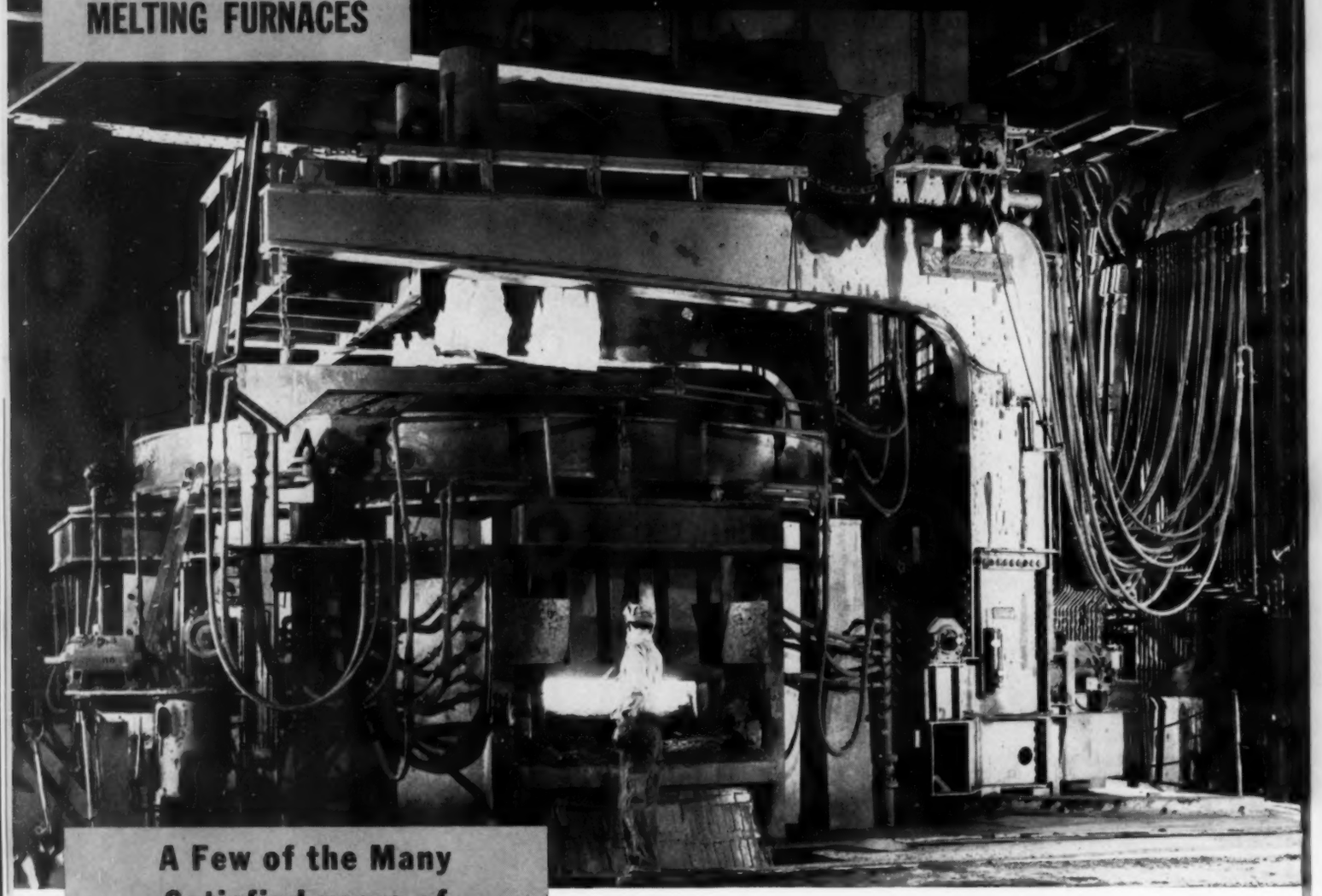

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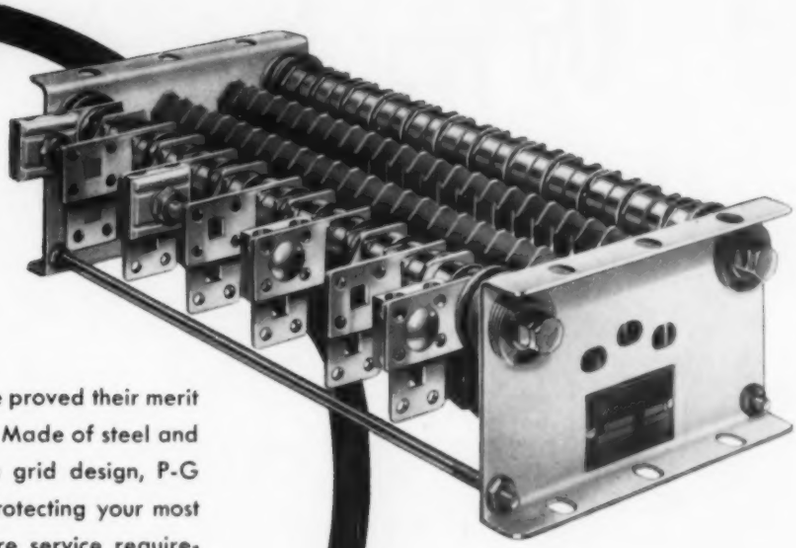

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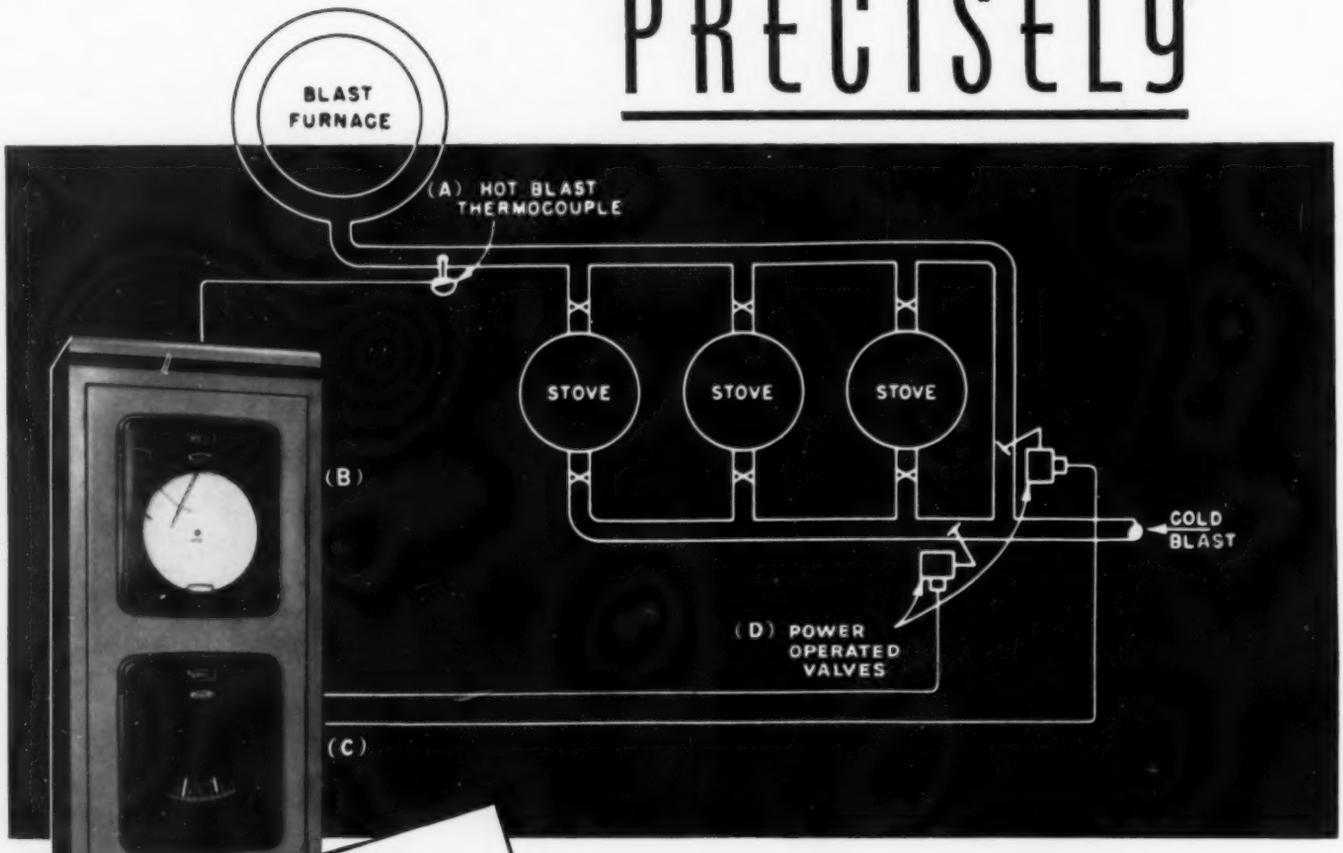

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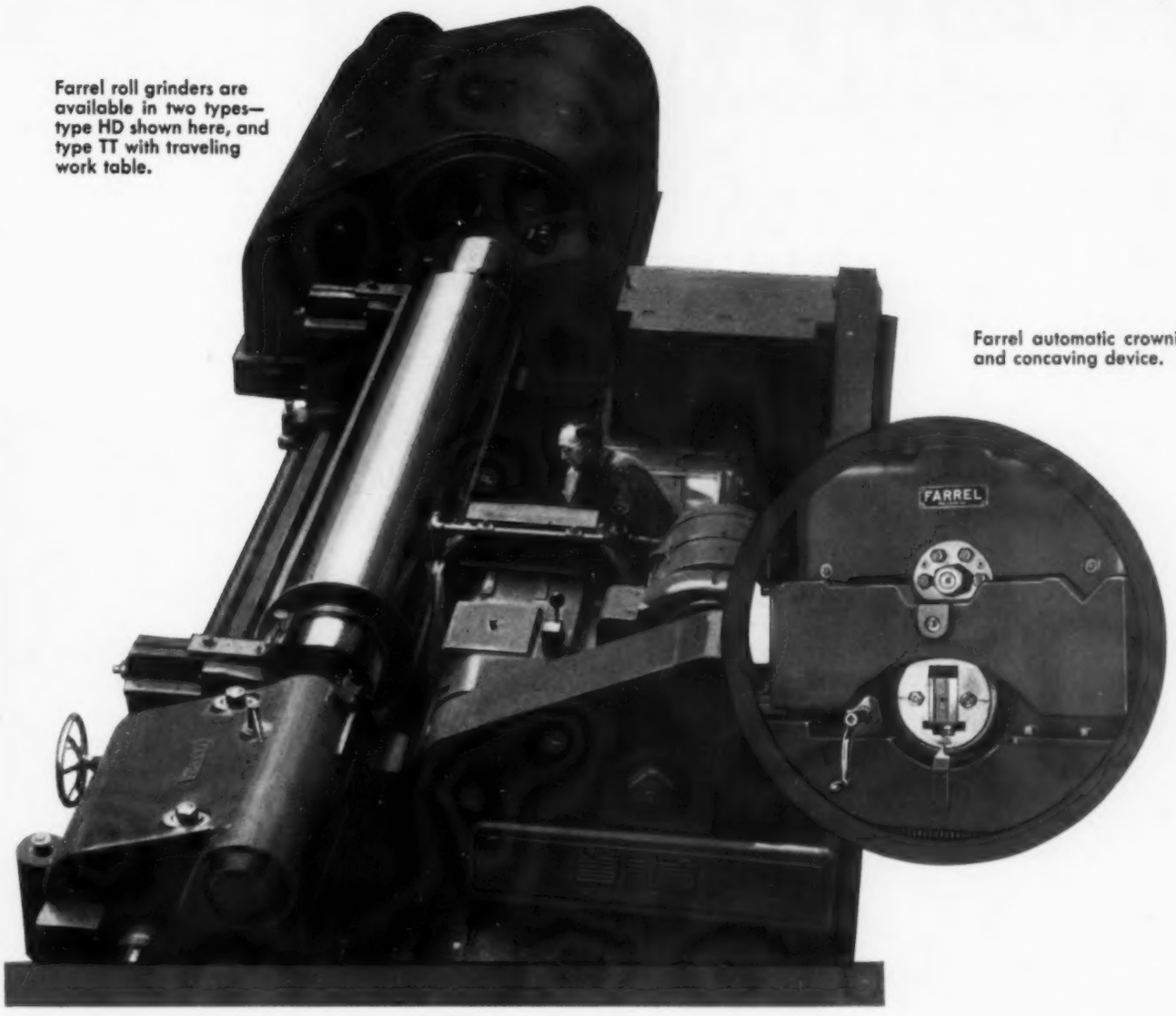

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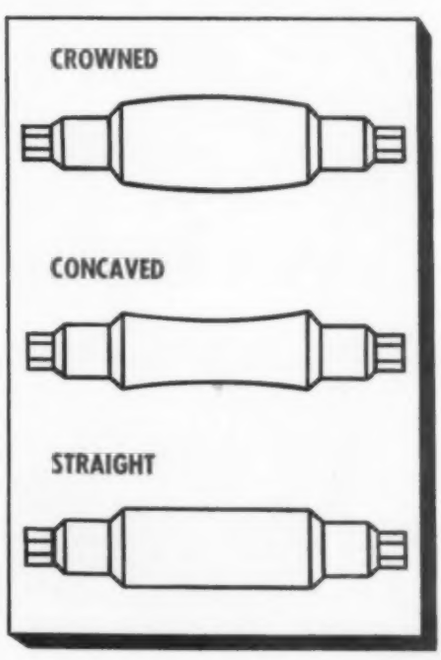

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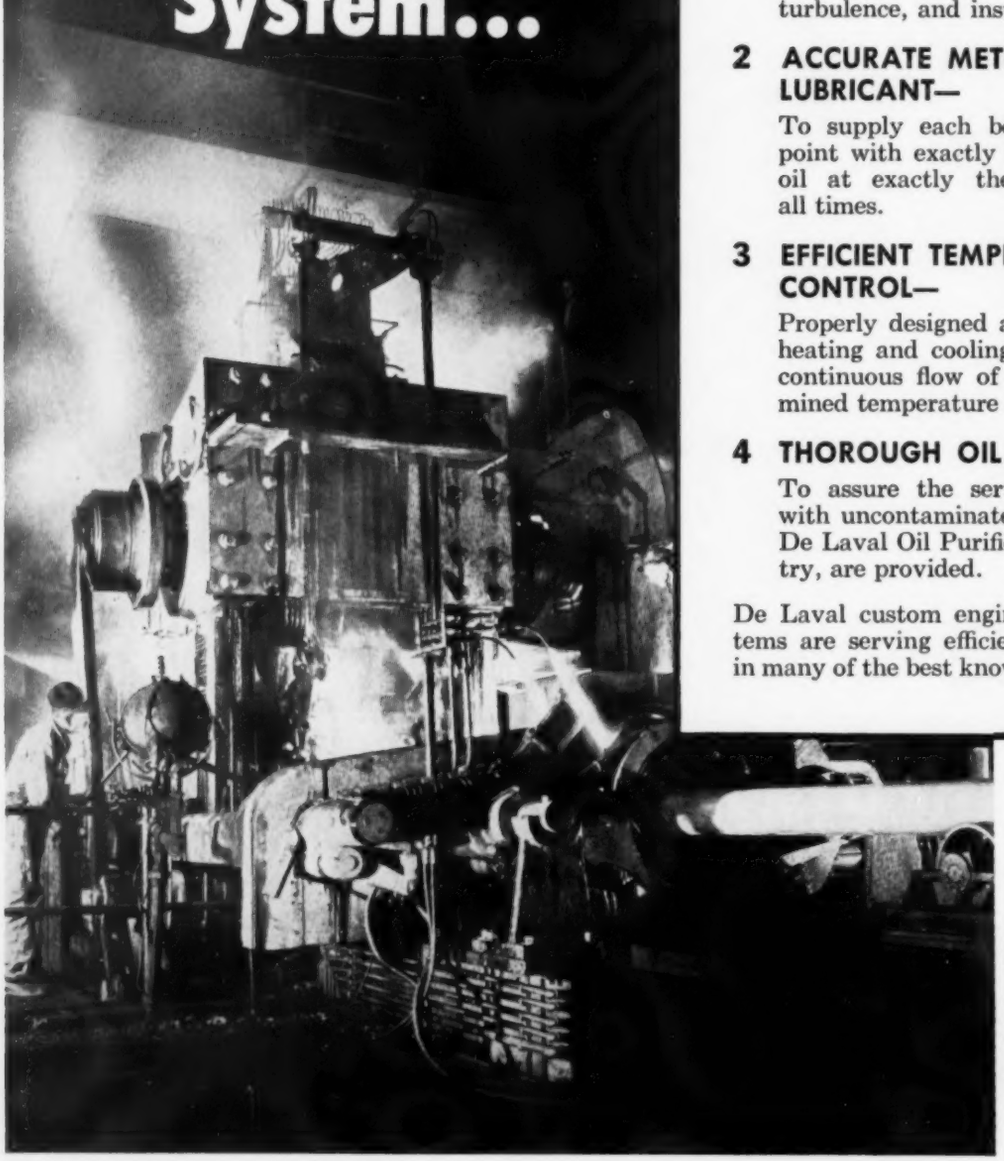

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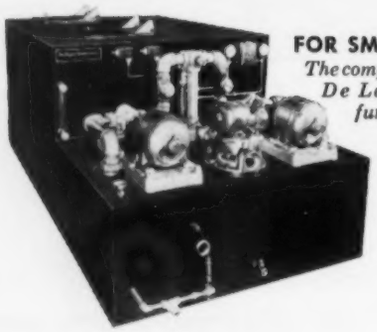

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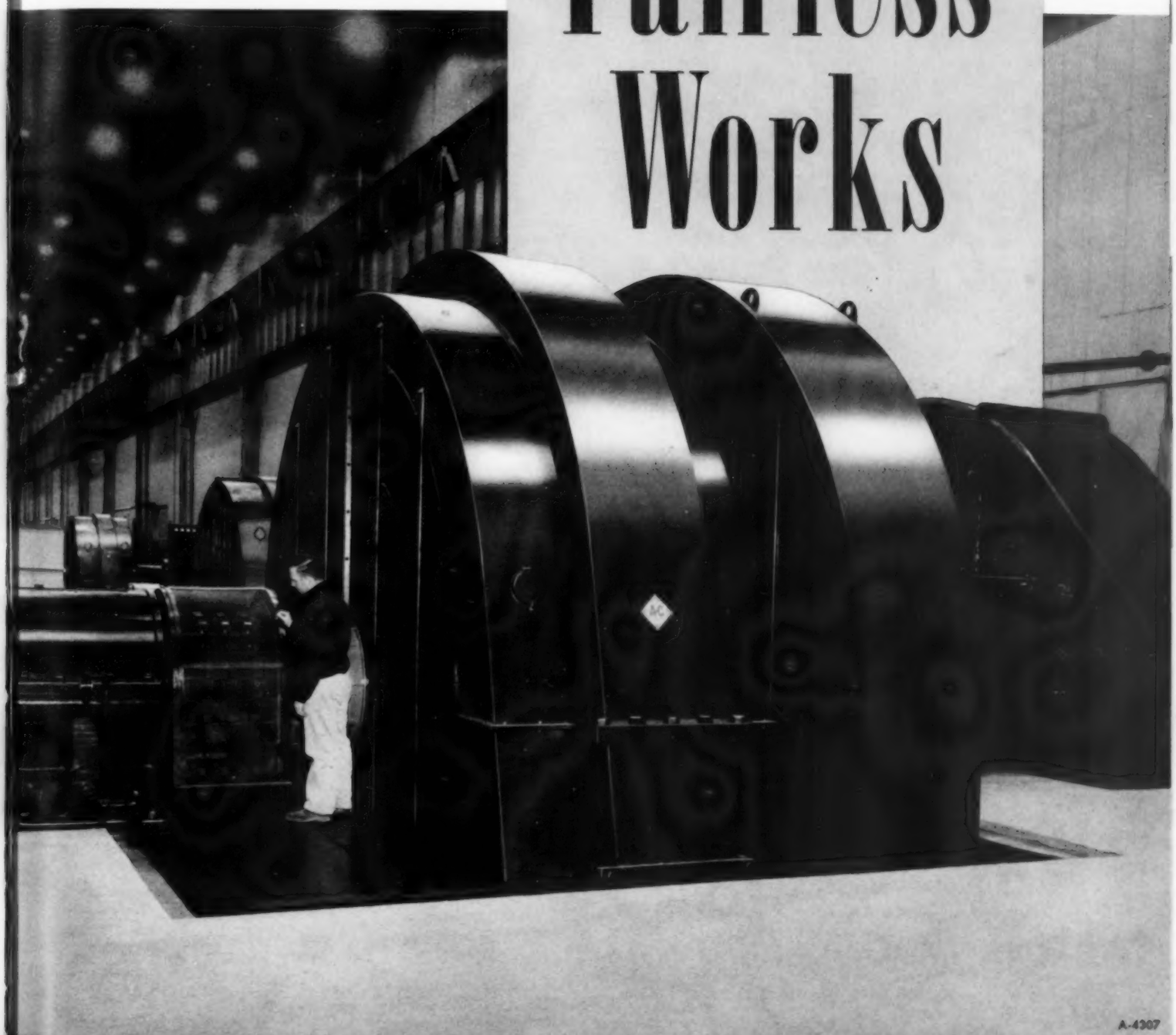

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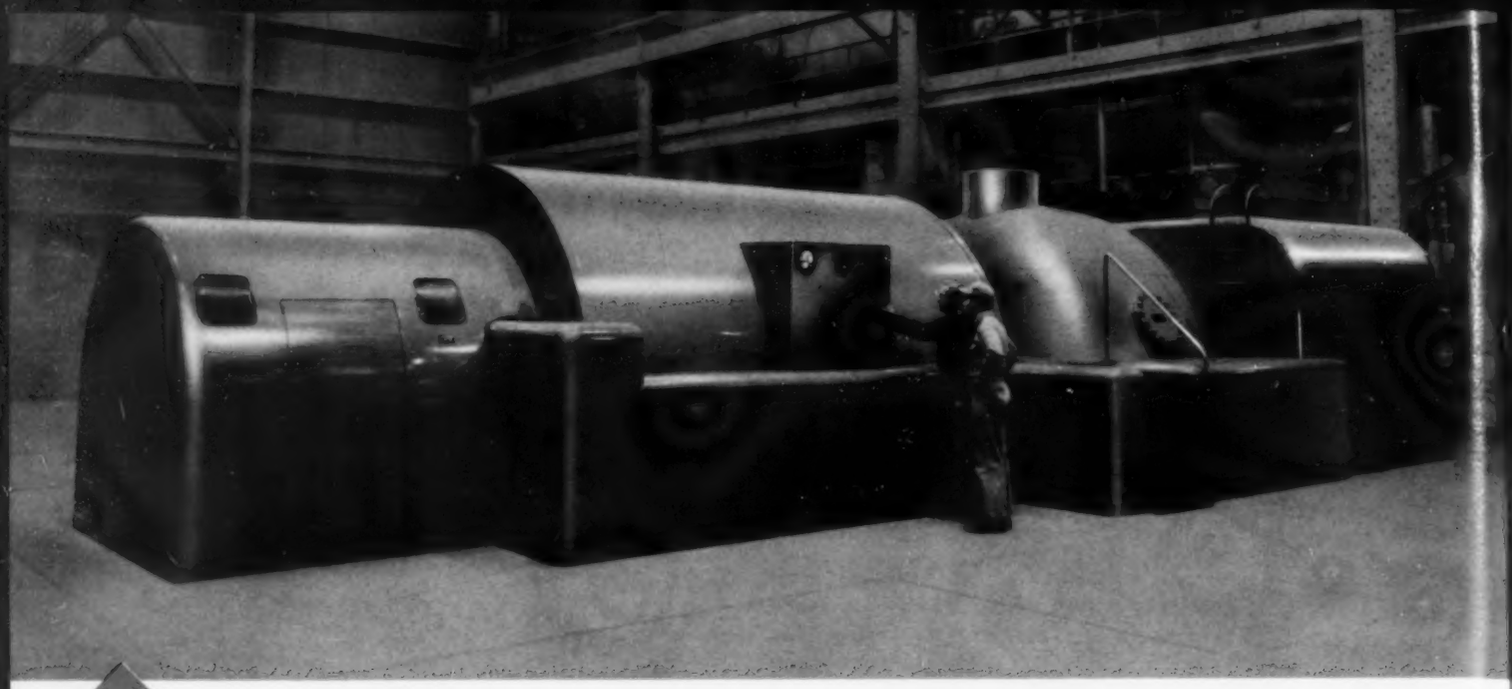
ALLIS-CHALMERS

MILWAUKEE 1 WISCONSIN



33,000 kw of steam-electric power for Fairless. Turbine features include accessibility of stop and inlet valves, centralized operating controls, self-contained and automatic steam-sealed gland system, above-the-floor oil piping and effective control of horizontal and vertical thermal movements. The generator offers simplified hydrogen seals and control, spiral stator ventilation, flexible core mounting, and "walk-in" exciter housing.

Double-armature twin drives power this two-stand tin temper mill. Driving the No. 1 stand at left are four 150-hp dc armatures. Four 200-hp armatures comprise the No. 2 stand drive at right.

Another Allis-Chalmers first . . . voltage, current and tension regulation of the two-stand tin temper mill is provided by magnetic amplifiers which offer the most modern refinements to the control circuits.

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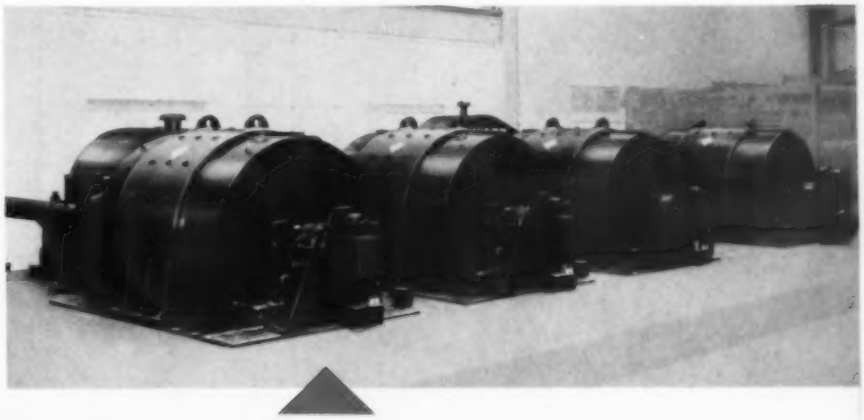
Again, as in other important mills of this vital industry, Allis-Chalmers was called upon to furnish a wide variety of equipment designed for steel mill duty.

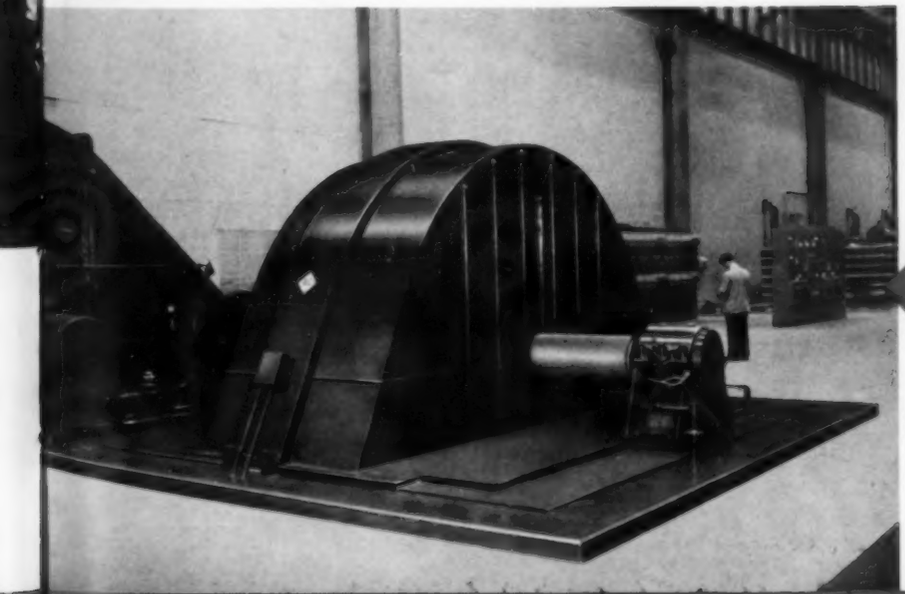
Rolling steel requires tremendous power, a part of which is produced by an Allis-Chalmers 33,000-kw turbine generator unit. *All* 250-volt direct current for material handling . . . from ore to finished steel . . . is supplied by A-C rectifier units totaling 25,000 kw and located throughout the plant for maximum efficiency. Important rolling operations for billet mills, hot strip mill, and the two-stand tin temper mill are accomplished with controls, motors and generators designed and built by Allis-Chalmers.

For specific information on controls, drives and other electrical equipment to meet the needs of your expansion or conversion program, contact the nearby A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin.

Allis-Chalmers controls, motor-generator sets, and drive motors for the 30-in. billet mill. Left background shows the 8000-kw m-g unit powered by an 11,200-hp synchronous motor, variable voltage control panel, and a 3-unit 180-kw exciter m-g set. The six drive motors are rated 1750 hp, 300/600 rpm, 600 volts dc.



Four 1250-hp, 400/800-rpm, 600-volt dc motors driving four stands in the 21-in. continuous billet mill. Variable voltage controls, 4000-kw synchronous m-g set, and a 130-kw exciter m-g set for this mill were also furnished by Allis-Chalmers.



One of four universal roughing stand drives in the 80-inch hot strip mill. Operating in conjunction with the 3500-hp broadside wound rotor motor shown on the cover, these four 6000-hp synchronous motors provide power for reducing large slabs. Other A-C motors in this mill include a 2000-hp synchronous scale breaking motor and two 500-hp wound rotor motors for a vertical edger.

CHALMERS

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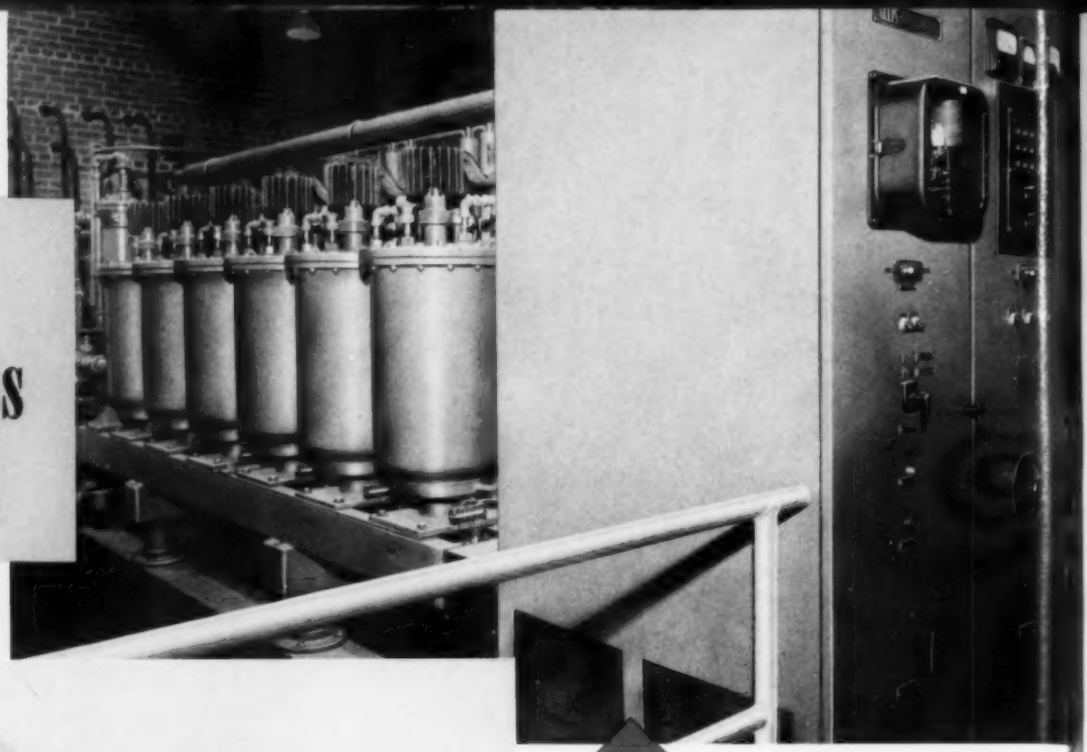
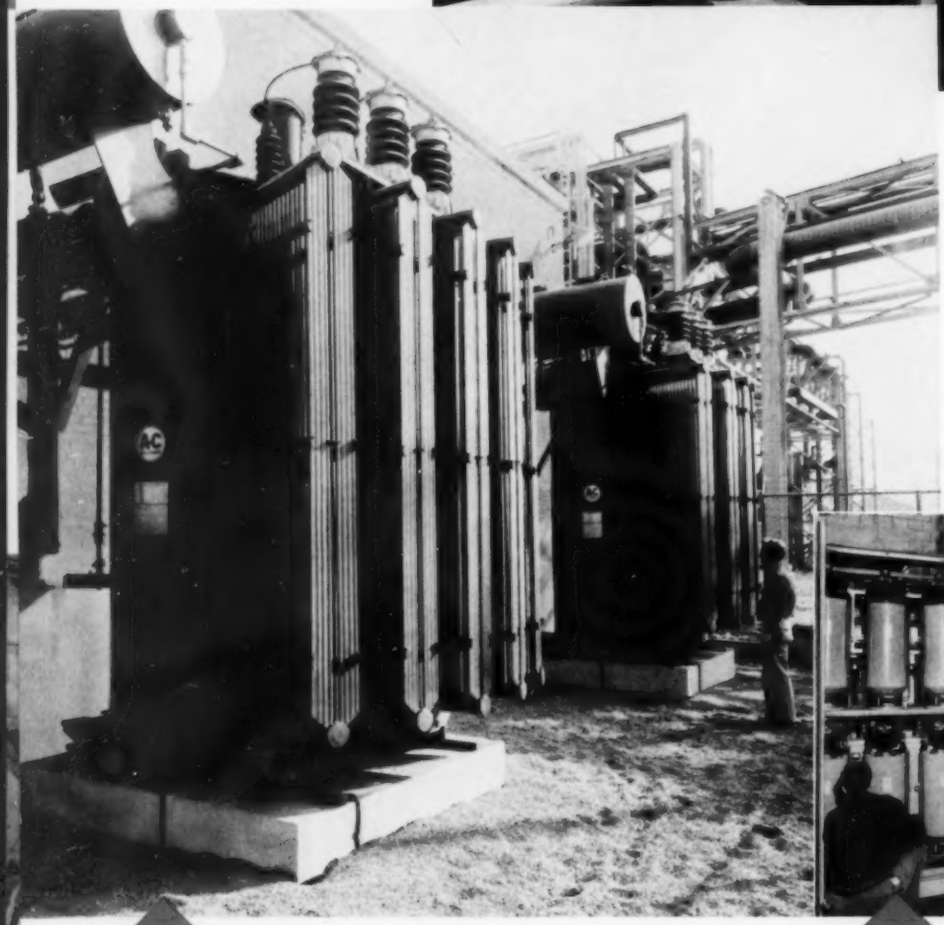
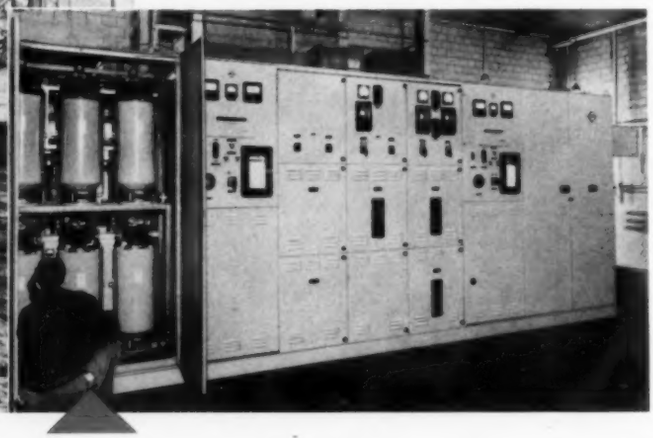
Serving

Fairless Works



One of two 1500-kw, 250-volt rectifiers supplying direct current to cranes, pig casting machines, bailer, slag cars, and stock house equipment in Open Hearth Furnace area. Each unit substation is designed for a three-phase, 13,800-volt, 60-cycle supply and is suitable for starting and stopping by manual or remote control.





Outdoor type main transformers for two 1500-kw, 250-volt rectifier units in the Open Hearth area. These transformers are oil insulated self-cooled, with built-in interphase reactors, and are provided with ground level tap changers for ease of operation, and broad flanged wheels for use on rails or flat surfaces.

Two 500-kw, 250-volt metal-clad rectifier units supplying dc service to coke plant pusher and coke handling equipment in the Coke Oven area. Units are factory assembled and wired, complete with dc switchgear and transformers. Both rectifier units feed a common load, providing maximum availability at all times.

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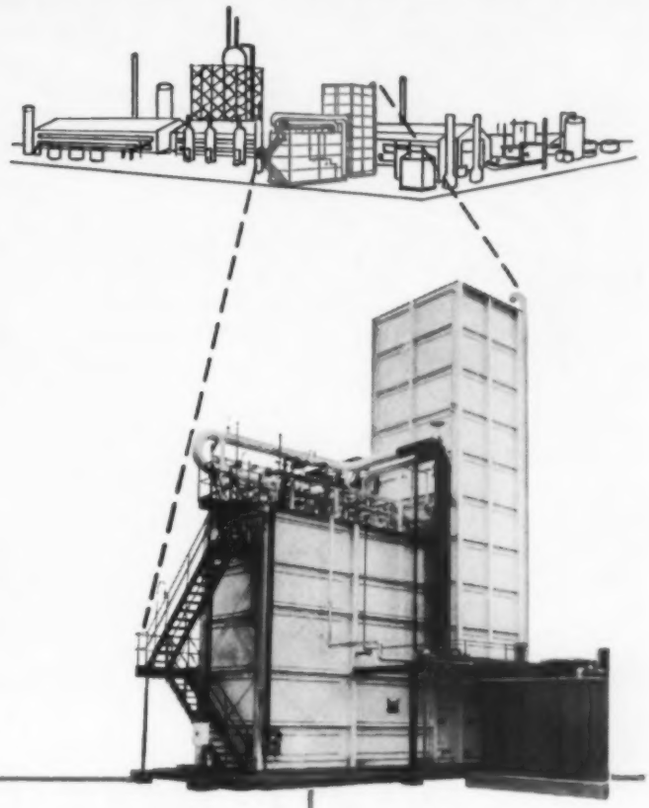
Entrust this important portion of your steel plant to *Air Products* INCORPORATED



Best Cycle for Your Requirements

High or low pressure cycle, according to your particular needs. *Air Products* is experienced with both for unbiased appraisal.

Engineering Staff Always Available

. . . through planning, process design, fabrication, erection, start-up, and on through the years of operation.

Integrated Engineering-Manufacturing Service

Engineering staff at the scene of manufacture. Allows best transposition of engineering skill into completed apparatus.

Specialists in Low-Temperature Processing

Air Products has designed and built over 600 low-temperature plants for gas separation. Trouble-free progress from planning to start-up.

Modern Production Equipment and Methods

Small parts made on mass production equipment . . . sub-assemblies made on assembly lines. Moving parts are interchangeable.

Service Points throughout the U.S.

Air Products' skilled erection-service engineers and technicians . . . plus stocks of spare parts . . . are located at strategic points in the U.S.

Your requirements for oxygen and/or nitrogen . . . whatever purities, capacities, pressures you need . . . can be obtained at lowest final cost with an *Air Products* Tonnage Generator. *Air Products* does the complete job maintaining close cooperation with you. Progress is smooth, fast. You get the best possible design and most dependable equipment. You save engineering time . . . maintenance costs . . . costly down-time. Talk it over with us! *Air Products Incorporated, Dept. P Box 538, Allentown, Pa.*

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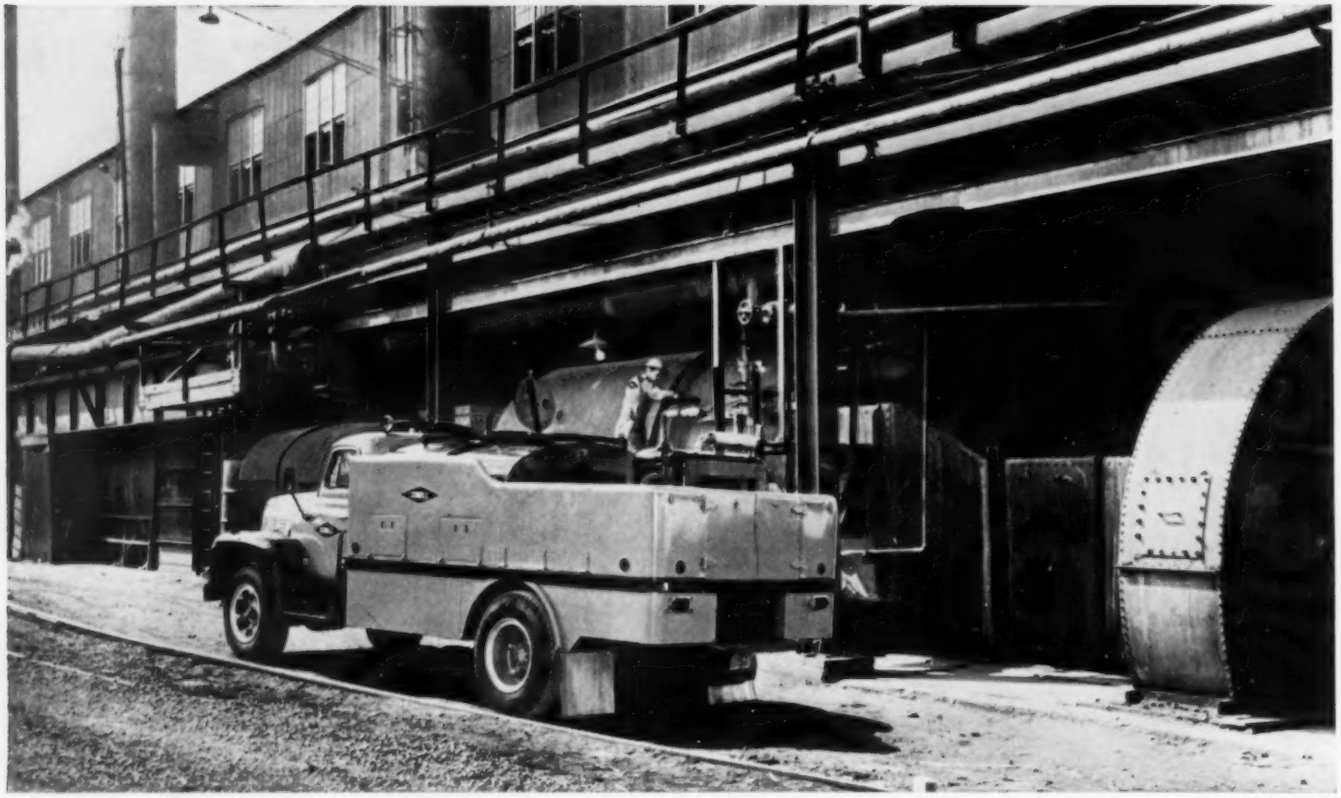


WASTE HEAT BOILER CLEANED BY DOWELL IN 13 HOURS

Inspection after chemical cleaning showed boiler free of scale—danger of burning tubes minimized

The water side of a waste heat boiler had become fouled with scale. Cleaning of the unit was necessary to avoid the risk of burning the tubes. Dowell was called to do the job.

In just 13 hours, Dowell engineers cleaned the 6,000-gallon capacity boiler, using chemical solvents. The unit was found to be metal-clean upon inspection after the job was completed—thus the risk of burning the tubes was reduced to a minimum.

Many types of boilers, heat exchange and process equipment have been cleaned by Dowell's chemical methods . . . *without dismantling and with a minimum of downtime.* This service has saved thousands of man-hours and helped to prevent costly repairs and replacements.

Perhaps chemical cleaning could improve the efficiency of equipment in your plant. Dowell engineers do the job for you. They bring specially prepared solvents in truck-mounted tanks right to the job, along with all necessary pumping and control equipment. They apply the liquid solvents according to the technique demanded by the job: filling, spraying, jetting, cascading or vaporizing. The chemicals go wherever steam and water flow, reaching surfaces inaccessible to other methods. Often equipment may be cleaned while in operation.

A Dowell engineer will be happy to discuss your cleaning problems with you—make estimates, if you wish—no obligation, of course. For more facts about Dowell Service, call the nearest of more than 130 offices, or write directly to Department H-29, DOWELL INCORPORATED, TULSA 1, OKLAHOMA.

DOWELL SERVICE

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

July 1

▲ U. S. Steel Corp. announced an upward adjustment in steel prices equal to approximately $3 per ton. This was a result of the recent increase in production costs due to the settlement made with the United Steelworkers. Other leading companies followed suit.

July 3

▲ The Independent Steelworkers Union at Weirton Steel Co. approved a 12¢ wage pension insurance settlement. Over 11,000 production and maintenance employees will receive a 5¢ hr wage increase plus insurance and pension improvements.

July 5

▲ The AISI reports operating rate of the steel industry for the week starting July 5 is scheduled at 59.7 per cent of capacity. This is equivalent to 1,424,000 tons compared with 1,568,000 tons one week ago and 2,092,000 tons one year ago. Index of production for the week is 88.6.

July 7

▲ According to the Commerce Dept., business inventories fell below year-ago levels for the first time since Korea. On May 31, stocks of manufacturers, wholesalers and retailers were valued at $79,600,000,000, a drop of $714,000,000 from the preceding month-end level.

▲ The Secretary of the Treasury reported Government debt totaled $270,800,000,000 on June 30 which was $5,300,000,000 above the level one year ago.

July 8

▲ According to the Labor and Commerce Depts., construction outlays rose to $3,300,000,000 in June, 3⅓ per cent above a year ago, which brought building expenditures to a record $16,600,000,000.

▲ June employment gained 979,000 over May and remained unchanged in contrast to its usual sharp June rise. Total employment in June was 62,098,000.

▲ The Aluminum Association reported primary production of aluminum in May 1954 totaled 250,175,582 lb as compared with 240,867,314 lb in the previous month and 210,953,111 in May one year ago.

July 12

▲ Auto dealers sold 561,200 new cars during June which was an 8 per cent increase over one year ago, the only month this year when sales exceeded the corresponding month for the previous year.

▲ Erie, Nickel Plate and Lackawanna railroads will put piggyback service into operation very soon. Expected to follow shortly are the Pennsylvania, Baltimore and Ohio and the Wabash.

▲ The AISI reports operating rate of the steel industry for the week starting July 12 is scheduled at 65.4 per cent of capacity. This is equivalent to 1,559,000 tons compared with 1,430,000 tons one week ago and 2,134,000 tons one year ago. Index of production for the week is 97.1.

July 13

▲ A bill was passed by the House requiring the Government to continue operating its Texas City tin smelter through next June.

▲ Dominion Foundries Steel, Ltd. will construct a new 56-in. strip mill costing $3,500,000 at its plant in Hamilton, Ontario, Canada.

July 14

▲ Personal income for May ran at a yearly pace of $285,200,000,000 or $800,000,000 above the April rate, but $1,100,000,000 below May 1953, as reported by the Commerce Dept.

▲ National production of goods and services in 1953 rose to a record $364,900,000,000, the Commerce Dept. announced.

▲ According to The Aluminum Association, primary aluminum production in the United States in June 1954 totaled 241,360,488 lb in comparison with the 250,287,697 lb in May and 208,303,690 lb in June 1953.

July 15

▲ The F. W. Dodge Corp. reports contracts for future construction in the 37 states east of the Rockies smashed records in June with a total of $1,733,264,000, the highest for any June, and 43 per cent ahead of June 1953.

▲ Republic Steel Corp. reported earnings of $2.22 a common share in the second quarter ending June 30 compared with $1.79 a common share in the first quarter of 1954 and $2.46 in the June quarter of 1953. Total revenues in the second quarter were $218,139,584 with a net profit of $13,712,933 compared with $305,261,138 and $14,931,475 for the second quarter of 1953.

July 16

▲ Dividend payments in May by U. S. corporations totaled almost $228,000,000, which is a 2.5 per cent increase over May 1953, as reported by the Commerce Dept.

▲ Sales and revenues of Allegheny Ludlum Steel Corp. for the second quarter of 1954 totaled $39,671,054 with net earnings of $828,221 or 44¢ per share of common stock. This compares with $65,632,845 sales, $2,163,275, or $1.25 profit for same quarter in 1953. Sales for first six months of 1954 totaled $85,285,193 with profit of $1,891,671 or $1.01 a share.

July 19

▲ According to the British Iron and Steel Institute, steel production for the first six months of 1954 hit a record 10,500,000 net tons. The BISI predicts an output of 20,400,000 net tons for the year 1954 compared with 19,400,000 net tons produced in 1953.

▲ Deliveries of new domestic freight cars in June 1954 totaled 2650 compared with 3173 in May and 6463 in June 1953 as reported by the ARCI. Orders in June totaled 1139 cars leaving a backlog of cars on order as of July 1, 1954 at 13,860 compared with 15,615 on June 1.

▲ The AISI reports operating rate of the steel industry for the week starting July 19 is scheduled at 66.0 per cent of capacity. This is equivalent to 1,573,000 tons as compared with 1,534,000 tons one week ago and 2,128,000 tons one year ago. Index of production for the week is 97.9.

July 20

▲ On sales of $116,422,718, net earnings of $6,081,216 equal to $1.82 per share were announced by The Youngstown Sheet and Tube Co. for the second quarter of 1954 compared with sales of

$104,312,290, and net earnings of $2,989,478 for the first quarter of 1954. In the second quarter of 1953, sales totaled $141,032,802 with earnings of $7,985,231.

July 23

▲ The American Steel & Wire Div. of U.S. Steel Corp. announced it will be closing its open hearth furnaces at Worcester, Mass. in the near future. This will affect about 10 percent of its 3300 employees at this plant.

▲ The federal deficit for the year ending June 30 was $3,029,000,000.

▲ Follansbee Steel Corp. reported that certain substantial financial interests have offered to purchase the company's assets. The proposal will be set before the shareholders shortly.

▲ Detroit Steel Corp. reported net loss of $329,763 or 13¢ per share for the second quarter compared with a net loss of $237,980 or 10¢ a share in the preceding quarter.

▲ Granite City Steel Co.'s earnings for the first six months of 1954 dropped sharply to $1,549,932 or 79¢ a share as compared with $3,199,869 equal to $1.85 a share for the first half in 1953.

July 24

▲ Lukens Steel Co. had a net income of $1,735,041, after provision for income taxes, for the first three quarters ended July 3 of its 1954 year. Income for the period was $5.45 a share. This compared with a net income for the corresponding period in 1953 of $3,207,126 or $10.08 a share. Net sales totaled $54,855,696 compared with $69,666,509 for the first three quarters of 1953.

July 26

▲ Announcement was made of the consolidation of the Damascus Tube Co. of Greenville, Pa. and Swan Engineering Co. of Bloomfield, N. J.

▲ Armco Steel Corp. announced net earnings for the first six months of 1954 of $19,001,116 or $3.64 per share. The 1953 period showed net earnings of $16,078,533 or $3.08 per share. Second quarter 1954 sales were $135,725,096 with a profit of $9,863,891 or $1.89 a share compared with the first quarter in 1954 with sales of $131,346,000 and net earnings of $9,137,226 or $1.75 a share.

▲ The AISI reports operating rate of the steel industry for the week starting July 26 is scheduled at 64.5 per cent of capacity. This is equivalent to 1,538,000 tons compared with 1,557,000 tons one week ago and 2,087,000 tons one year ago. Index of production for the week is 95.7.

▲ The AISC reports June shipments of fabricated structural steel amounted to 290,262 tons, an increase of 14 per cent over the previous month. Total shipments for the first half of 1954 were 1,621,793 tons compared with total shipments of 1,560,470 for the first half of 1953. Sales in June totaled 219,306 tons leaving a backlog as of June 30 of 1,390,613 tons.

▲ Machine tool builders in June booked the largest amount of new business since last October. Orders increased to $55,000,000, 34 per cent over May.

July 27

▲ U. S. Steel Corp. reported income for the second quarter at $49,020,738, or $1.63 a share. Income for the first half of 1954 is reported at $93,851,114 as compared with $105,016,764 for the first six months in 1953.

▲ Jones and Laughlin Steel Corp. reported net income for the second quarter of 1954 at $6,326,000 or 96¢ a share compared with $5,821,000 for the first quarter. For the first six months of 1954 net income was $12,147,000 or $1.84 a share. Sales and operating revenues for the second quarter were $133,486,000 compared with $127,880,000 for the first quarter.

▲ United Engineering and Foundry Co. reported a net income of $1,486,958, equal to 59¢ per common share for the first six months of 1954 as compared with $2,043,709 equal to 82¢ per common share in the corresponding six months of 1953. Sales totaled $27,246,531 for the first six months compared with $39,974,547 last year.

July 28

▲ Crucible Steel Co. of America reported net income for the June 30, 1954 quarter at $782,470 compared with an income of $2,165,641 for the corresponding quarter in 1953. Income for the first six months of 1954 was $1,312,395 compared with $3,922,470 in 1953, on sales of $84,555,951 and $126,388,737 respectively.

▲ Inland Steel Co. reported a record net income of $19,417,669 or $3.92 a share for the first half of 1954 compared with an income of $15,677,521 or $3.20 a share for the corresponding period in 1953. Net income for the second quarter of 1954 was $9,954,419 compared with $8,872,371 for the corresponding 1953 period. Sales in the 1954 second quarter totaled $141,028,039 compared with $151,439,684 in 1953.

July 29

▲ According to The Aluminum Association, primary production in the first half of 1954 was 1,430,652,841 lb or almost 20 percent over the same period of 1953 and almost as much as during the entire year of 1950.

▲ Wheeling Steel Corp. reported a net profit for the quarter ending June 30, 1954 of $3,247,638 equivalent to $1.97 per share compared with $2.56 a share in 1953. Profits for the first six months of 1954 amounted to $4,383,024 or $2.45 per share. Gross sales for the first six months were $94,942,720, down 15 per cent.

July 30

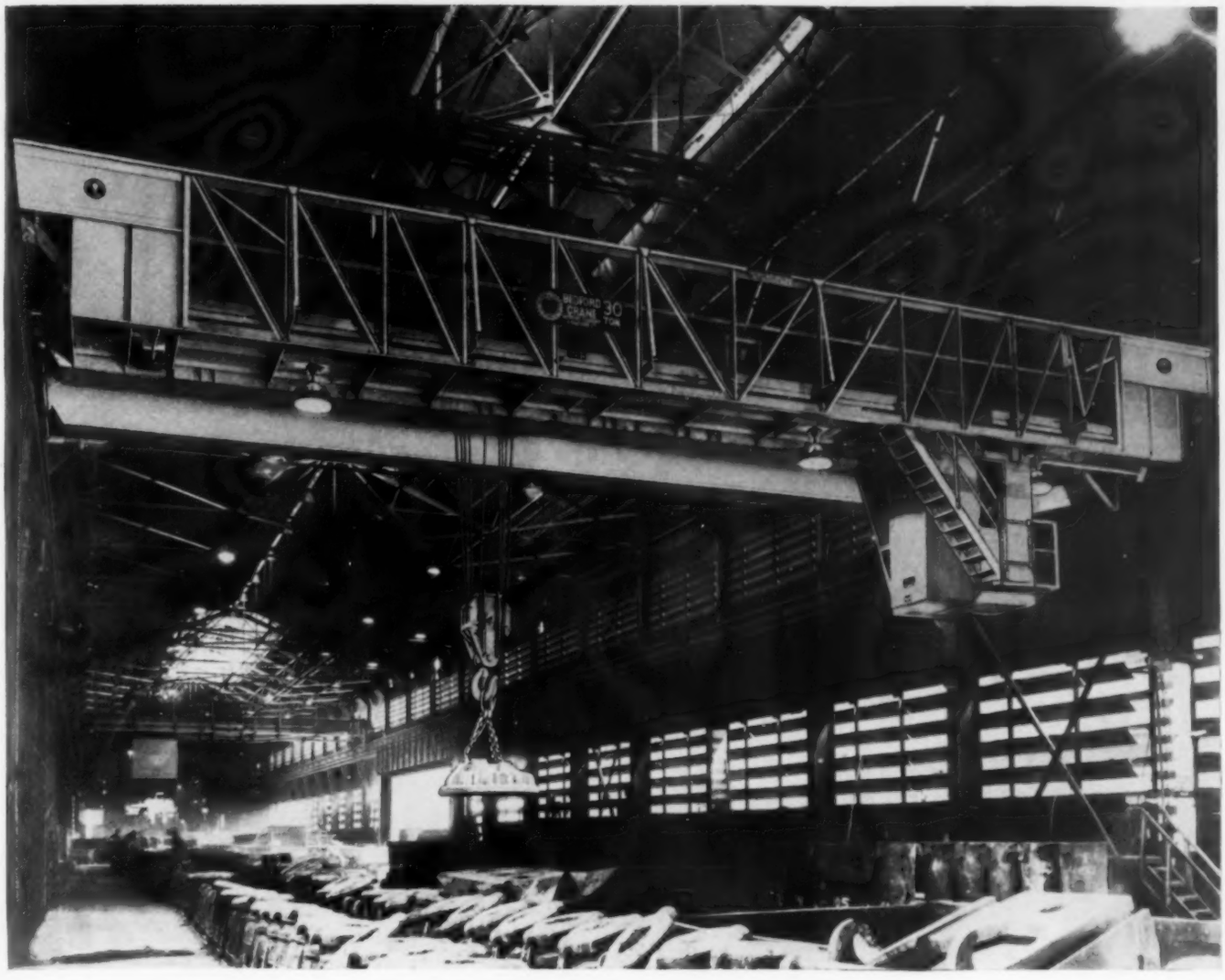
▲ Talks have been held on possibility of merging Bethlehem Steel Corp. with Youngstown Sheet and Tube Co.

▲ The Colorado Fuel and Iron Corp. reported the operations for their fiscal year ending June 30 resulted in net income of $7,051,729 equal to $2.46 a share on common stock. This compares with the previous year's net income of $8,031,224 or $3.09 per share on common stock. Total sales for the year were $250,235,696.

▲ National Steel Corp. reports net earnings for the quarter ending June 30, 1954 of $6,605,123 equal to 90¢ per share on sales of $121,427,694 which compared with earnings in the second quarter of 1953 of $12,989,799 equal to $1.77 per share on sales of $177,803,529. Earnings for the first six months of 1954 were $13,025,348 or $1.77 a share in comparison with earnings of the same period in 1953 of $24,074,732 or $3.27 a share.

▲ Sharon Steel Corp. reported for the second quarter of 1954 a net income of $573,546 equal to 52¢ a share. A net income of $644,262 equal to 58¢ a share was declared for the first six months ending June 30, 1954 compared with $4,100,967 equal to $3.73 a share for the first six months ending June 30, 1953. Sales for the first half of 1954 were $47,972,633 compared with $94,843,911 in 1953.

▲ Bethlehem Steel Corp. declares net earnings of $30,755,412 or $3.04 a common share for the June quarter as compared with the $2.81 share in the same quarter in 1953 and $2.73 a share in the March quarter. Sales for the first six months totaled $884,763,199 compared with $1,056,293,226 in 1953.



Another Bedford Mill Type Crane at Timken Roller Bearing Company

The Timken Roller Bearing Company has just installed a new 30-ton Bedford crane over the stripper building in their mill at Canton, Ohio. This is the second Bedford crane to be installed by the Timken Roller Bearing Company at Canton since July, 1952. The new crane has a 61′2″ span with 32′5″ lift. Built to AISE specifications, it has air-conditioned cab, worm drive gear on the hoist, and welded girders.

Proof of the superiority of Bedford cranes is found in the high percentage of repeat orders from important owners through the years.

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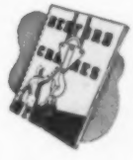
You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)



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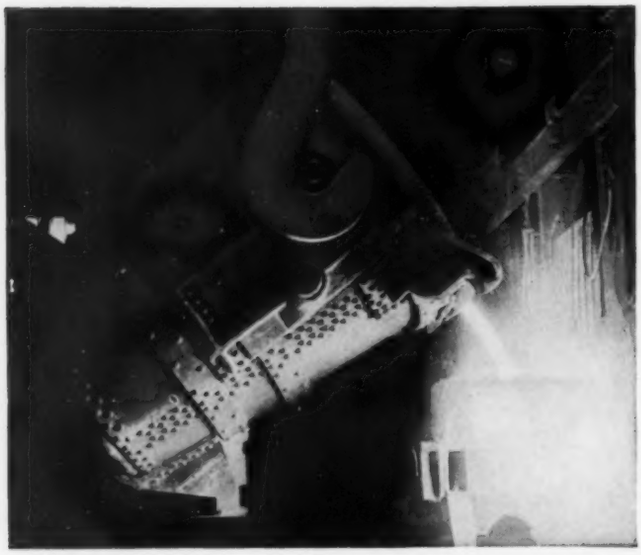

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THE CITIES SERVICE HEAT PROVER . . . Not an instrument that you buy . . . but a service we supply . . . **FREE!**

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Learn how the Heat Prover, supplied and maintained free by Cities Service, can benefit you. For details, contact your nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, New York City 5, N. Y.

See The Heat Prover in action at the Cities Service Exhibit at the Iron and Steel Exposition, Cleveland Auditorium, Sept. 28-Oct. 1. Booths 483 and 484.

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15-Ton unloaders with EC&M control set new records in unloading time and low maintenance costs at the Baltimore & Ohio, Curtis Bay Ore Pier

20,560 TONS OF IRON ORE UNLOADED IN 13 HOURS AND 55 MINUTES! Fast-operating EC&M Line-Arc Contactor Control with EC&M Time-Current Acceleration helped establish this record.

EC&M Control Apparatus and Control Engineering also provide outstanding safety during all operations. Power for motor drives is fed through operator's cab for safe, direct control. Dynamic braking for quick trolley stop is automatically applied in end-zones and if power fails. EC&M Quadruplex Controllers insure that the 4 bridge motors share the load equally and that brakes release and set uniformly.

Replacement part cost, in this installation, has been only 25¢ per 1000-tons of ore unloaded over a 3 year period. The record proves that high output with low upkeep is yours when you select EC&M Control.

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Industry News...

REPUBLIC ANNOUNCES $10,000,000 EXPANSION PROGRAM FOR INDIANA AND OHIO PLANTS

▲The largest appropriation made by Republic Steel Corp. since the steel industry production rate began to drop nearly a year ago was announced when the company's directors approved a $10,000,000 expansion and improvement program.

Largest part of the appropriations will be spent in Ohio's Mahoning Valley with more than $5,000,000 scheduled for new equipment in the company's plants in Warren and Youngstown.

Included in the new projects is continuous hot dip galvanizing equipment in Warren, signaling an important addition to Republic's diversified production facilities. In Youngstown a substantial amount will go for a hydraulic pipe expander to produce electric weld line pipe for higher pressure lines.

A new building and equipment at the Union Drawn Steel Division plant in Gary, Ind., new hot rolled strip coiling equipment in the Cleveland district and a new building and equipment at the Culvert Division plant in Canton, Ohio are also included.

In announcing the appropriations, C. M. White, president, declared, "Although the first six months of this year showed a sharp drop in steel production compared with 1953, we feel optimistic about the future of the steel business, Republic has shown that good earnings can be maintained with operations around 70 per cent of capacity."

Work is to commence immediately on the continuous hot dip galvanizing project at Warren. The new equipment will be installed in the present sheet and tin building and will increase the plant's finishing facilities by 9,000 tons a month.

The continuous strip galvanizing line, which will process cold rolled steel up to 48 in. wide, is being designed and built by Wean Engineering Co.

Coils of steel, up to 40,000 lb in weight, with a maximum thickness of 16 gage, will be continuously coated with zinc at the rate of about 300 ft a minute. Length of the entire line will be about 600 ft.

The new Republic line will permit processing of a wide range of accurately tempered steels, since the coils will be annealed and temper rolled before entering the galvanizing line.

The hydraulic pipe expander to be installed in Youngstown will produce electric weld line pipe with improved physical properties to meet the need for higher pressure oil and gas lines now being more widely used throughout the country.

The equipment will cold expand and test 8⅝-in. to 16-in. line pipe in lengths up to 48 ft. The installation will require some relocation and rearrangement of existing equipment to provide the most advantageous material flow.

Other appropriations for the Warren and Youngstown plants include improvements of pickling facilities, roll turning equipment, alterations to an uncoiler, a new strip width gage and a thickness indicator for a cold strip mill.

The new building in Gary will house production facilities for an additional 1500 tons of carbon and alloy cold-drawn bars, and 600 tons of alloy cold-heading wire per month to meet increased demands of Midwestern customers.

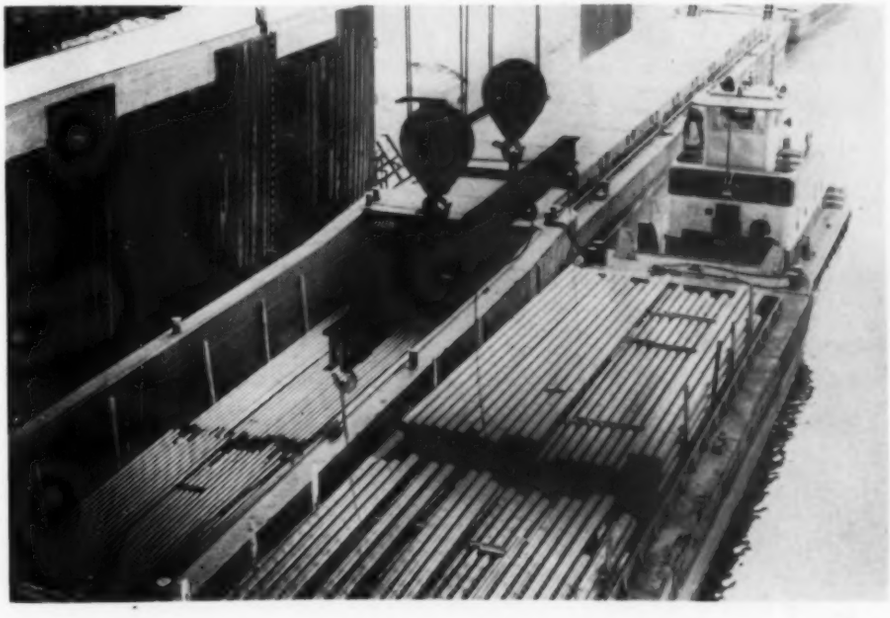
The nation-wide boom in superhighway and turnpike construction makes expansion of Republic's Culvert Division in Canton desirable. The new building will contain facilities for fabricating an additional 5,000 tons per month of sectional plate structures for highway drainage purposes.

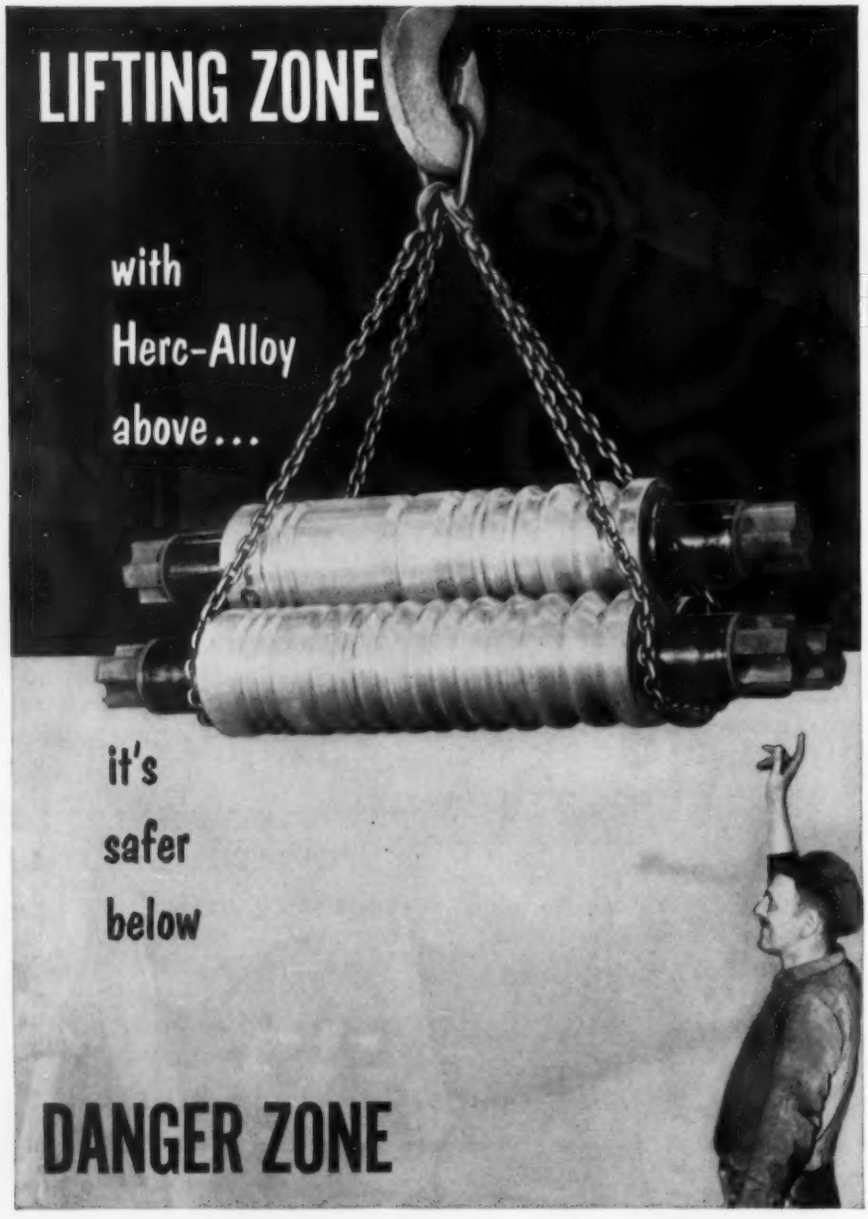
ORE PROCESS PLANT COMPLETED BY KAISER

▲Completion of a new plant designed to extract the maximum amount of iron ore from the high-grade deposits at Eagle Mountain, Calif. was announced by Kaiser Steel Corp.

SEAMLESS TUBING "SHOVES OFF" FOR ALASKA

A barge load of 500 tons of 8⅝ in. seamless steel tubing from the Aliquippa Works of Jones & Laughlin Steel Corp. prepares to embark on the first leg of a 9500-mile "all-water" trip. The pipe, part of an 8300-ton shipment, will be transferred to a freighter at New Orleans and shipped through the Panama Canal up the West Coast to Haines, Alaska. It is destined for installation in the new $30,000,000, 621-mile Haines-Fairbanks pipeline, being built by the U. S. Army to carry aviation, motor, jet and diesel fuels to military bases in the interior of Alaska.





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The Allegheny Ludlum Steel Corp., pictured above, uses Herc-Alloy Sling Chains for hundreds of tough lifting jobs in its plants. In addition to maximum safety, Allegheny Ludlum also enjoys the extra economy of longer-lasting Herc-Alloy. These sling chains offer still another advantage...a weight reduction unmatched by any other alloy chain without any sacrifice in tensile strength. This reduces worker fatigue. All things considered, don't you think Herc-Alloy Sling Chains are worth a try in your plant.

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The average iron content of the ore as mined from the open pit operation is 51 per cent, recognized throughout the industry to be high-grade ore. After being processed through the new facilities, the ore will have an average iron content of 56 per cent.

The first step in the process is a magnetic unit which attracts high-grade magnetite ore, just as a magnet will attract iron filings. The remaining ore (hematite) is then sent through a liquid solution where the higher-grade ore, which is heaviest, drops to the bottom and is taken off and combined with the high-grade magnetite ore for loading into railroad cars. The ore with lower iron content, being lighter in weight, is floated away by the solution and sent to a waste stockpile.

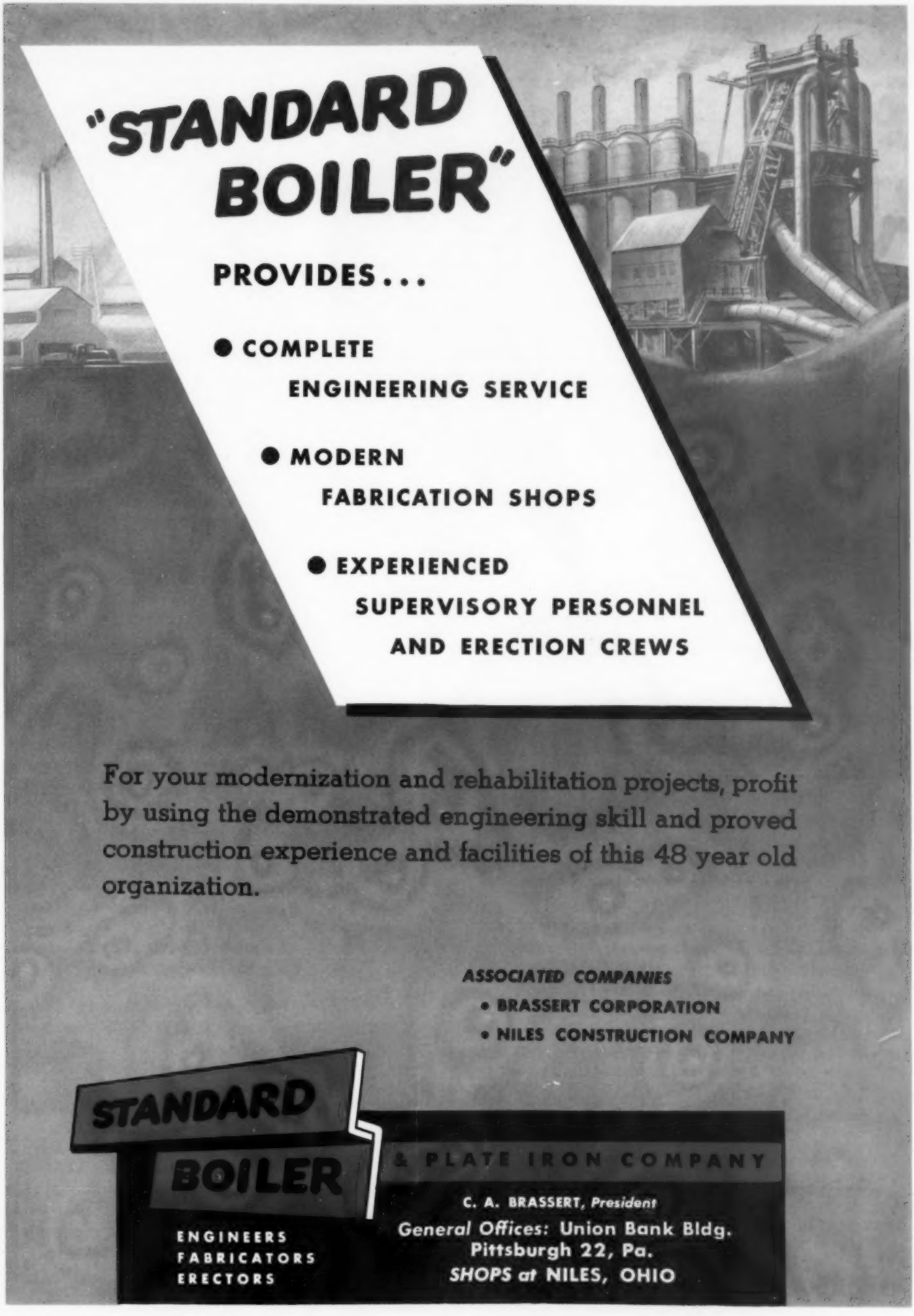
The plant, constructed by Kaiser Engineers Division of Henry J. Kaiser Co., is designed to process more than 2,000,000 tons of ore per year. The liquid solution which floats off the lower-grade ores is essentially a mixture of water and ferrosilicon, the formulation of which involved extended scientific studies to achieve the proper weight balance.

This marks another step in the company's extensive development program at Eagle Mountain, where deposits are sufficient to supply Kaiser Steel's operations for many decades.

LICENSES U. S. STEEL FOR HIGH-TOP PROCESS

▲ Signing of a license agreement by the U. S. Steel Corp. with Arthur D. Little, Inc., of Cambridge, Mass., who introduced and pioneered high-top pressure operation of blast furnaces, has been announced. This process, which is essentially the pressurizing of the top part of the furnace, has increased the daily output of those blast furnaces already converted by as much as 15 per cent.

Dr. Earl P. Stevenson, president of the Cambridge research organization, in calling this development one of the most significant advances in ferrous metallurgy, indicated that the successful application and acceptance of the process came only after several years of basic research in the ADL laboratories followed by pilot-plant operation and demonstration to the steel industry.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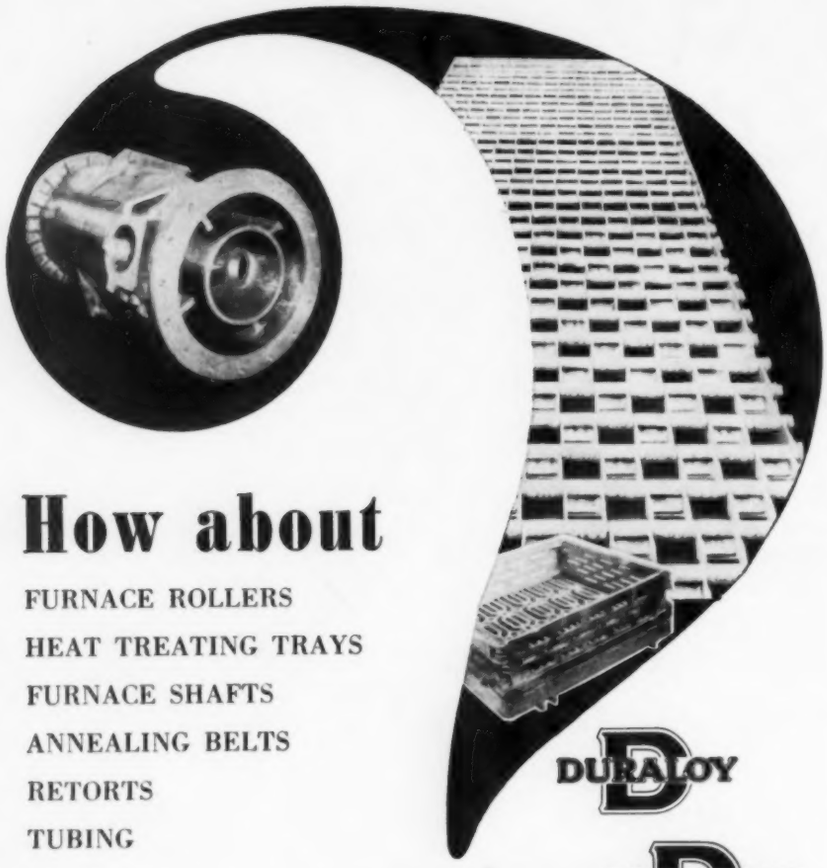

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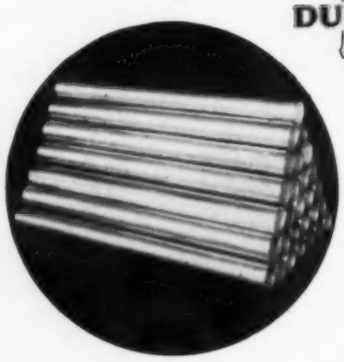

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The high-top pressure process was first tried experimentally during World War II by cooperation between the War Metallurgy Committee and Republic Steel Corp. In 1953 an all-time company record of pig iron production was set, using one of Republic's pressurized furnaces. This production of 574,028 tons of iron ranks it among the top producing furnaces in the country.

Today there are nine licensed pressurized furnaces in operation in the U. S. Licenses for the process have also been granted English and European steel companies, and it is known that Russia has converted many of its furnaces to the new process, although "without licenses." It was announced recently by the British Broadcasting Co. that the U.S.S.R. Zaporoyhye Iron and Steel Works had converted their four blast furnaces to top pressure operation. These four are in addition to at least seven others known to have been converted to pressure behind the Iron Curtain.

The top pressure operation is accomplished by throttling the gases from the furnace. The reducing gas is thus slowed down and pressure built up in the furnace. In addition to increased output the consumption of coke is reduced and flue dust losses are reduced by more than a third. The cost of installation is about two per cent of the original furnace cost.

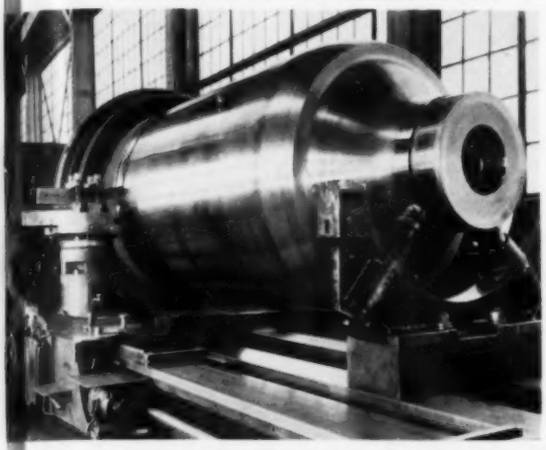
B & W TO BUILD ATOMIC HEAT EXCHANGER UNITS

▲ A contract to furnish two heat exchangers for the first full-scale nuclear power plant ever built in the U. S. has been signed by the Babcock & Wilcox Co. The contract is with Westinghouse Electric Corp. which has responsibility for the nuclear portion of the project under an agreement with the Atomic Energy Commission.

The Duquesne Light Co. will build the electric-generating portion and will operate the power plant which is to be located on a site near Shippingport, Pa.

"The two Babcock & Wilcox heat exchangers are a new design which involves less expensive materials and fewer complex shop operations than those used in any previous units of this type," said C. H. Gray, vice president in charge of B & W's Atomic

PRESSURE CYLINDER



Operator machines a pressure cylinder on a 110-in. lathe at the Mesta Machine Co., in West Homestead, Pa. This is one of the eight cylinders in the 50,000 ton hydraulic forging press which Mesta is building for the U. S. Air Force. These cylinders were forged from alloy steel ingots weighing 198,500 lb each and are machined to an inside diameter of 5 ft-½ in. with 10-in. wall thickness and 11 ft-7½ in. long.

Energy Division. "This is in keeping with the major aim of the project which is to demonstrate the economic feasibility of nuclear power."

NEAR COMPLETION ON ARMCO PROJECT

▲ The $10,000,000 expansion program at Armco Steel Corp. Ashland Works is rapidly nearing completion.

In addition to the $40,000,000 hot strip mill completed last year, new facilities include a four-high 58-in. cold reversing mill, a continuous strip pickler, and two Armco Zincgrip lines. The Zincgrip units, one heavy gage and one light gage, coat strip steel with zinc in a continuous operation. The process is patented by Armco.

The cold reversing mill and the continuous pickler are now in operation and the light gage line will start production within a few days. The heavy gage unit, which will process steel as thick as 10 gage, is expected to begin operation within two months.

These new facilities will add several new products to those already produced at Ashland. Hot rolled and pickled coils will now be turned out at the plant, in addition to both light and heavy gage sheets.

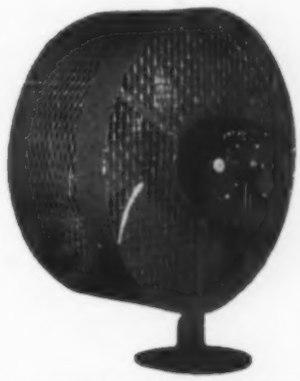
The new facilities embody the latest developments and improvements in steel plant equipment design. The cold reversing mill is powered by motors totaling 4500 hp and will turn out cold reduced strip at a maximum speed of 1650 per minute. The mill will process strip up to 48 in. in width.

The new Zincgrip lines have a greater capacity than any of the four similar units Armco already has in operation at its Middletown, Ohio, and Butler, Pa. plants. The heavy gage line will coat steel up to 80 in. in width and the light gage line will process strip up to 50 in. wide.

Engineering and construction of the new facilities began in the spring of 1953, and new buildings were especially built to house them.

A third phase of expansion at the Ashland Works is also well along. Additional coiling, shearing, and slitting equipment will be installed this year, and added storage space for material-in-process and finished products is also under construction.

IS HEAT SLOWING UP YOUR WORKMEN?



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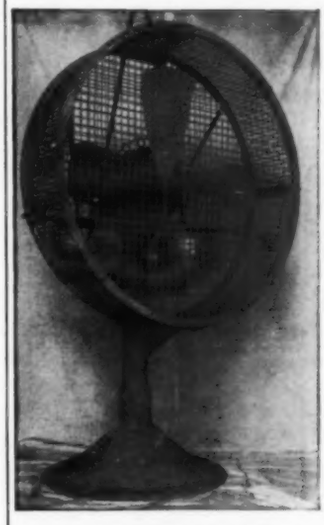

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Oxygen—and LINDE SERVICE —in action:

(Photo made at Great Lakes Steel Corp., Detroit Division of National Steel Corp.)

EIGHT-TON COILS of 60- to 77-inch-wide sheet steel are usually composed of four lengths of steel welded together. Users, such as the automotive industry, lose time and material cutting out these welded joints. Now, a major steel producer has met this problem with a remarkable new slabbing mill. Instead of 2½ or 3-ton slabs, this mill turns out 8-ton slabs, each of which is rolled into a single, weld-free coil up to 1,828 feet long, in .0359 inch thickness.

Size wasn't the only key to the success of this mill. Its output had to be flawless. That's where oxygen and LINDE SERVICE came into the picture. Working with plant engineers, LINDE designed and built a LIN-DE-SURFACER scarfing machine as a part of the mill.

As the slab passes through the LIN-DE-SURFACER, oxygen jets burn surface scale and defects off the top and bottom simultaneously, at speeds up to 160 feet per minute. The conditioned slab is then ready for rolling into flawless one-piece coils of high quality sheet steel.

This is another example of how LINDE Oxygen and LINDE SERVICE serve the steel industry. LINDE SERVICE is the unique combination of research, engineering, and more than 40 years of accumulated know-how that is helping LINDE customers save money and improve production in their uses of oxygen and oxy-acetylene processes.

If your company uses oxygen, LINDE SERVICE can mean dollar savings to you. Let us tell you how.

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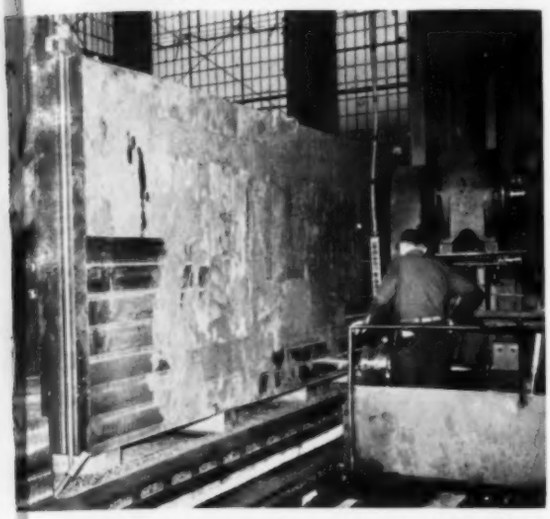

Made from a 55-ton ingot of Hardtem die steel, this block, after rough-machining and heat treating, was delivered as a 23-ton hardened and tempered die holder for use in a 15,000-ton hydraulic press at the Cleveland plant of Aluminum Co. of America. Two of the die holders, each 78¼ in. by 168 in. by 12¼ in., were produced by Heppenstall Co. After forging, each block was given a preliminary machining, as illustrated, by running a milling machine back and forth across its face.

U. S. STEEL CHRISTENS NEW SHIPPING POINT

▲ Upwards of 3,000,000 tons of high-grade dolomite limestone, will be shipped annually from Port Dolomite, the new shipping point of Michigan Limestone Division of U. S. Steel Corp.

The new port is located between McKay and Bush Bay on Lake Huron 34 miles south of Saulte Ste. Marie. Its name comes naturally from the product of the quarries which lie five miles inland near the town of Cedarville.

Under the supervision of Michigan Limestone's chief engineer, Thomas C. Jackson, and C. R. Dolsen, operating manager of the quarry and plant port, 125 construction employes are developing a large acreage of limestone-bearing property with a goal of beginning production in late fall and shipping the first boatload of limestone next spring.

Construction crews which began work in April of 1953 by moving in most of the equipment and supplies on trucks, are presently pushing the railroad line from the quarry down through five miles of rugged terrain and swamp. A primary crusher is being erected on the floor of the quarry which is 46-ft below the surface.

Plans call for the stone to be hauled over the new rail line from this crusher to the Port Dolomite area where a secondary and tertiary crusher and screening plant of about 1800 tons per hour capacity will process the stone into eight grades ranging from 3 x 5 flux stone to rice size just over $\frac{1}{16}$-in.

One of the outstanding units among the new facilities is the 620-ft long and 117-ft wide dock which stands at the edge of a natural water channel leading out into Lake Huron. Channel depth is 26-ft from low water datum. The unique feature of the dock is the traveling loading shuttle which enables a boat to tie up and be filled in about five hours' time without being moved back and forth to receive the various sizes of limestone available at the plant. The

The combination of heat and wear resulting from high speed travel as steel runs through a mill guide continually works towards its destruction. For this severe application a material is required which combines heat and wear resistance with adequate strength—all are inherent properties of these guides made by Rosedale Foundry and Machine Company.

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TO HOLD LUBRICATION CONFERENCE IN OCTOBER

▲ A joint Lubrication Conference sponsored by the Lubrication Activity Committee of the American Society of Mechanical Engineers, and the American Society of Lubrication Engineers will be held at the Lord Baltimore Hotel, Baltimore, Md., October 18 and 19, 1954.

A total of 20 papers will be presented at five sessions covering Rolling Element Bearings, New Developments in Hydrodynamic Lubrication, Bearing Instability, Hydrostatic Bearings, and Materials and Lubrication.

This Joint Lubrication Conference will be open to all members of both ASME, ASLE, and guests.

COKE OVEN CONTRACT AWARDED TO WILPUTTE

▲ Wilputte Coke Oven Division, Allied Chemical & Dye Corp., has been awarded a contract for the design and construction of three 64-oven batteries of Wilputte coke ovens with auxiliary equipment for the Clairton, Pa., works of U. S. Steel Corp.

The 192 new Wilputte ovens will replace the present three batteries now being dismantled.

ARMCO ANNOUNCES BAR MILL PROJECT

▲ A $85½ million project to install new rolling facilities at its Baltimore Works, was announced by Armco Steel Corp.

The project will consist of a bar mill for the rolling of stainless steel in a wide variety of sizes and grades. The mill which will be housed in a new 550-ft building, is scheduled for completion in about 18 months.

SIGNS AGREEMENT FOR SINTERING UNIT

▲ Heyl & Paterson, Inc., has signed a sales agreement with Charles E. Agnew of Cleveland, Ohio, giving Heyl & Patterson exclusive marketing rights to the Agnew Sintering Machine.

This agreement enables the company to offer to industry complete facilities for the design, fabrication and erection of complete sintering plants. Mr. Agnew will serve in a consulting capacity in the application of this equipment.

The Agnew Sintering Machine was developed and patented by Mr. Agnew after many years of study and experience in the sintering field. It contains exclusive improvements and patented devices designed to reduce initial, operating and maintenance costs as well as to increase production and improve the quality of the finished product.

ANNOUNCES FORMATION OF NEW GE DIVISION

▲ Formation of the Chemical and Metallurgical Division within the General Electric Co. has been announced by Robert Paxton, executive vice president of the company.

The new Division includes the former Chemical Division and the Carboloy Department. Robert L. Gibson has been appointed general manager of the division, and will make his headquarters in Pittsfield, Mass.

The new division will be made up of five operating departments: Carboloy, Plastics, Silicon Products, Chemical Materials, and Laminated and Insulating Products.

Chemical materials and plastics departments are headquarters at Pittsfield, Mass., while Silicone Products and Laminated and Insulated Products Departments are headquarters at Waterford, N. Y., and Coshocton, O., respectively.

FOLLANSBEE ADOPTS NEW DIVISION NAME

▲ Follansbee Metals is the new name for the former Follansbee Metal Warehouses, a division of Follansbee Steel Corp., Pittsburgh, Pa. According to J. H. Dowling, assistant vice president, the name change was effective August 1.

Mr. Dowling said the decision to adopt the new name was based on it being a more accurate description of the services rendered by the division's depots for metals in Pittsburgh, Rochester, N. Y., and Wallingford, Conn.

He added that no change in policy, procedure or personnel was involved in the adoption of the new name.

NATIONAL CARBON COMPANY'S

CARBON AND GRAPHITE NEWS

IN THIS ISSUE

". . . . . *Open-hearths may be hard to find,*" is the interesting observation by our Guest Editor. See the feature article by. . . . . .

William B. Wallis, Past President of the American Foundrymen's Society and currently President of the Foundry Equipment Manufacturers Association.

". . . . . *a myriad of new and useful products in the creative inferno of the electric arc.*" A review of other arc-furnace applications.

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As the oldest and largest supplier of carbon and graphite products, National Carbon Company has contributed to this great industry by continual product improvement through ever-expanding research and development. Our Company is proud of this contribution but also is fully aware of its responsibilities to continue to serve steelmakers. We must not only produce even better products for you, but we must tell you about them and about other developments in the fields where these products are used.

To this end, a regular series of reports, of which this is the first, is being sponsored by our Company, covering significant developments in steel-mill and foundry practice involving the electric furnace.

To bring you the most complete, up-to-date information, we plan to make a major share of these editorial pages available to recognized authorities outside our own organization . . . men who, as consultants, design engineers, metallurgists, furnace operators and manufacturers, have distinguished themselves in their respective fields.

The vital business of making iron and steel — better and more economically — remains a constant challenge. Subsequent issues will present information on ways in which this challenge is being met.

A. F. Johnson

PRESIDENT

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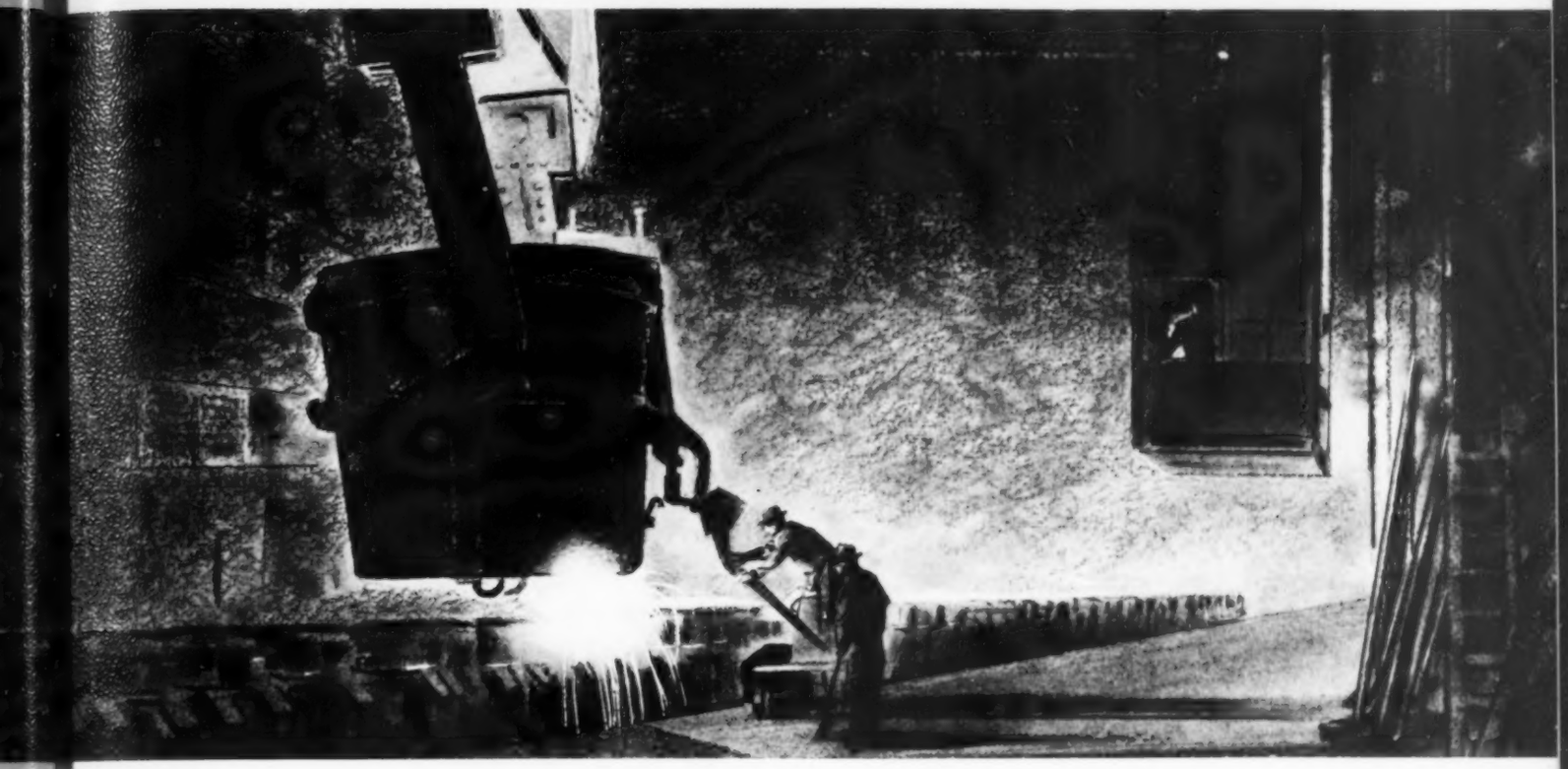


ELECTRIC FURNACE STEEL—
PAST, PRESENT AND FUTURE...*by W. B. Wallis*

IT HAS been my good fortune to watch the development of the electric arc furnace in both the ingot and casting fields over a number of years. At no time in the past forty years of active participation in the industry has the picture been as bright as it is today.

With this healthy and encouraging prospect in view, it seems appropriate to inquire into the reasons why this now-widely accepted instrument of steel production was so long in coming of age in a country famous for the speed of its technological progress.

EARLY FACTORS RETARDING GROWTH

The electric arc furnace entered the American steel industry during the period between 1906 and 1920, when the country was producing a relatively large quantity of steel each year and was annually increasing that quantity at a rapidly-accelerating rate. Furthermore, the electric furnace was not christened as a common-steel producer, but rather as a specialized tool for the making of special steels to replace products of the crucible.

In its approach to the common-quality steel picture, the electric furnace was compelled, thirty-two years ago, to go into the small, independent mills. From that early beginning it developed very slowly to the making of billet-size ingots for reinforcing rods – a type of ingot production that was of no interest to the tonnage producer. Electric-furnace installations were made in Texas, Alabama, Washington, Indiana, Tennessee, Ohio and Pennsylvania as a result of the Canadian success in producing the first billet-size ingots. Canada also was first to install thirty-ton electrics for the production of common-quality steels. It is important to point out that it was this background of *gradually* accelerating electric-furnace production of common steels in the smaller mills that slowly brought the arc furnace to the attention of the big ingot producers.

RECENT FACTORS ENCOURAGING GROWTH

Electric-furnace steel production experienced a meteoric increase of 60 per cent during the four-year period between 1949 and 1953. Responsible and informed analysts of our steel economy have attributed this rapid growth to the availability of top-charging furnace designs and high-powered substations.

Their theory does not check completely with the record nor explain all the facts.

Figure I sets up the progress of top-charge, high-powered furnace installations in the U. S. A. Clearly, the 1949-53 growth did not wait upon modern furnace design or adequate power facilities – these had been available for twenty-two years. Nor can we reasonably suppose that this accumulation of experience with top-charging practice suddenly, and for no other, more basic reason, flowered into unprecedented acceptance.

Rather, to adequately understand and explain this sudden increase in electric-furnace capacity, we must look at the record of *common*-steel production in this country since 1910 – a record which may help to explain why electric-furnace growth was so long in coming.

In Figure II, the per cent of increase in total steel production is related to corresponding percentage increases in electric-furnace production for the periods 1910-20, 1920-40, 1940-49 and 1949-53. Right up to 1949, we find a fast-growing overall-production pattern, paralleled by relatively sluggish growth in electric-furnace capacity. Tonnage figures shown for each period indicate the huge *mass* involved in the industry's increasing *velocity* of growth – MV^2, if you will, always far ahead of any other in the world.

The first significant break in our steel industry's constantly accelerating MV^2 came in 1949. Then, for the first time, American steel producers had *time* to evaluate electric-furnace economics in the light of:

PROGRESS OF TOP-CHARGE ELECTRIC FURNACE INSTALLATIONS IN THE U. S. A.

Year	Size of Furnace	Size of Substation	Kw/ft.² Hearth Area	Tonnage Per Heat
1927	11 ft.	5000 KVA	100	12 tons
1929	12 ft.	5000 KVA	78	20 tons
1938	15 ft.	12500 KVA	110	30 tons
1940	17 ft.	15000 KVA	98	50 tons
1948	18 ft.	16000 KVA	90	70 tons
1949	19 ft.	18000 KVA	90	85 tons
1950	20 ft.	25000 KVA	110	95 tons
1951	22 ft.	36000 KVA	127	135 tons
1954	24 ft.	36000 KVA	104	150 tons
1954	24'-6"	25000 KVA	69	175 tons

FIGURE I

1. Large-capacity, high-powered, top-charge furnaces.
2. Almost a generation of experience with this accepted, modern type of design.
3. Most importantly, an industry whose tremendous mass-acceleration had reached, for the first time in 43 years, a condition of equilibrium.

At least one observation is quite obvious: that expansion of the electric furnace since its beginning in the United States has been inversely proportional to the mass-acceleration of the steel industry as a whole. If this fact suggests, as it does to the writer, a theory valid in the explanation of our own electric-furnace history – its long, slow growth and sudden expansion–the same theory should be equally valid when applied to electric-furnace development abroad. Such definitely is the case, as shown in Figure III. Here again, electric-furnace steel production experienced its greatest growth during the period when the European steel maker had *time* to study the electric furnace as applied to his economics. For example, prior to World War II, France and England had pushed their production of electric-furnace steel to about 11 per cent and Germany to about 7 per cent. Sweden and Italy, where tonnage factors were lower prior to World War II, each produced about 27 per cent of the national output by the electric-furnace process. Even in the one period (1920-40) during which the per cent increase, or *velocity*, of production elsewhere in the world exceeded our own, the total *mass* involved abroad never approached that established early in this country's history.

EFFICIENCY OF ELECTRIC FURNACE vs. OPEN-HEARTH

A most interesting report was made in 1953 by the Bituminous Coal Research, Incorporated[1]. In this well-known report the Battelle Memorial Institute takes a look at the open-hearth furnace, long the standard ingot producer in this country, and points out that only about 25 per cent of the heat introduced in the open-hearth is delivered in the steel poured; whereas in the electric furnace, 75 per cent of the heat introduced is in the steel poured, all of which means that future study of the open-hearth must consider more carefully this matter of overall heat-balance in an attempt to improve its efficiency.

On the opposite page, Figures IV and V are tables of heat balance as published on pages 31 and 32 of the Battelle Memorial Institute report.

ECONOMICS WITH COLD-SCRAP CHARGE

Steel production in this country is grouped into two types of plants: (1) 100 per cent cold-scrap plant; (2) the integrated plant. As the result of experience over the past nineteen years with high-powered, top-charge furnaces making common-quality steel, the ingot industry has accepted the fact that the electric furnace can produce common-quality steel ingots for less money than the open-hearth, where 100 per cent cold-scrap charges are used.

There recently have been two notable papers by members of the industry that emphasize the foregoing – that of Leo Reinartz[2], December 1953, before the American Iron and Steel Institute of Philadelphia, and the Howe Memorial Lecture by C. D. King[3], Feb. 16, 1954, before the A.I.M.E.

The electric furnace not only can produce ingots for less money with 100 per cent cold scrap, but, size for size, it can produce double the tonnage of the open-hearth on the same quality steel. As has been repeatedly pointed out, where cold-scrap charges are considered, the cost of electric-furnace plant buildings, cranes, ladles, etc., represents about 60 per cent of the investment required for an equivalent-capacity, open-hearth shop.

Furthermore, the electric furnace has considerable advantage over the open-hearth in the overall yield of ingots produced from scrap charged. Again, it has a higher availability than the open-hearth for the reason that the down times for relining are relatively short.

Figure VI gives hourly production rates on top-charged, higher-powered electric furnaces during the year 1953.

INTEGRATED PLANTS

Steel producers have accepted the fact that in cold-melt shops employing 100 per cent scrap, the electric furnace is a cheaper producer of ingots than the open-hearth. Some, however, are approaching consideration of the electric furnace as applied to integrated plants with a good deal of hesitation. There are three approaches to the use of the arc furnace in integrated plants: (1) Duplicating open-hearth practice; (2) duplexing blown metals; (3) oxygen blowing in the arc furnace.

DUPLICATING OPEN-HEARTH PRACTICE

There has been an aversion to attempting the duplication of open-hearth practice in the electric furnace because of a conviction that hot metal was "natural" for the open-hearth with its normally oxidizing atmosphere; while, on the contrary, it was an unnatural job for the electric furnace because of its neutral or reducing atmosphere. Nevertheless, experimental heats were tried over the past years, one of the earliest being made in the forepart of the war by Phelps[4]. Others tried their hand with varying results. In some plants the experiments came to one conclusion,

Total Steel Production Growth vs. Electric Furnace Production Growth

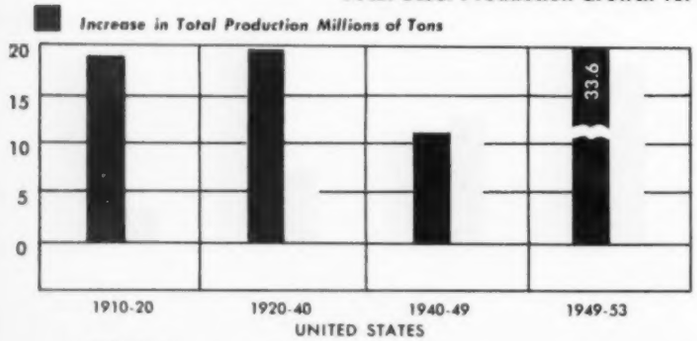


FIGURE II

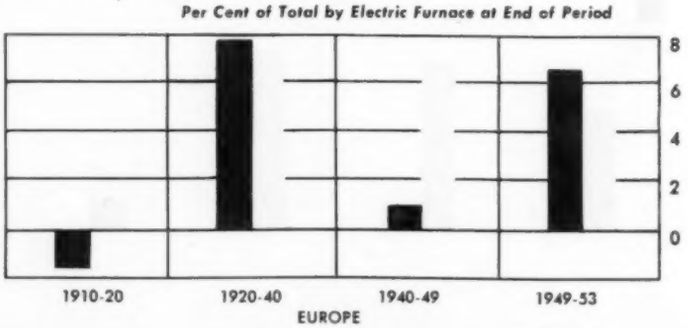


FIGURE III

namely, that while the job could be done, it was too dangerous to continue with the experimentation. They learned that, while some heats went along beautifully, the next heat might be of an explosive nature, endangering the lives of the furnace crew.

All of us recognize the fact that, in spite of the acceptance of the electric furnace as an ingot producer on a cold-metal-charge basis, the electric furnace could never be a real factor in tonnage production of ingots until there was developed a repetitive practice on hot metal.

In one plant in this country the use of hot metal in the arc furnaces has been continuous in regular production, starting with 25 per cent hot metal in the charge, gradually increasing to 40 per cent, where it now stands because of the limited availability of hot metal in the shop. We have been assured that on the 40 per cent hot-metal charge, practice has been standardized with all crews to the point where it is normal daily operation with exact control of the process. It can be said, in general, that there is found to be no saving in power or electrode consumption with this practice, but there definitely is a 10 per cent increase in the hourly rate of production of the furnace. Those in charge feel that there will be no difficulty in advancing the percentage of hot metal on regular repetitive practice to 50 per cent of the charge whenever the hot-metal supply is available in the shop. It is interesting to note that in a plant being built abroad, the installation is based upon the use of hot metal at 60 per cent of the electric-furnace charge.

The second doorway for the electric furnace into the integrated plant is that of duplexing. Duplexing of low carbon metal was used during World War I for the production of some types of alloy steel. It has been used on the Continent for years in converters for the production of various types of steels.

HEAT BALANCE OF OPEN-HEARTH FURNACE OPERATING ON A COLD-METAL CHARGE
(25 per cent pig iron, 75 per cent steel scrap)

	Btu per ton of ingots	Per Cent
INPUT		
1. Heat combustion of fuel	4,600,000	94.0
2. Sensible heat in fuel	115,000	2.4
3. Heat content in liquid pig iron	....	...
4. Exothermic reactions	175,000	3.6
Total	4,890,000	100.0
OUTPUT		
5. Heat content of liquid steel	1,260,000	25.8
6. Heat content of slag	186,000	3.8
7. Calcination of limestone	....	...
8. Reduction of iron ore	43,000	0.9
9. Evaporation and heating of water in charge	420,000	8.6
10. Loss in stack gases	1,340,000	27.4
11. Heat dissipated in cooling water	260,000	5.3
12. Loss through walls, radiation, etc.	1,381,000	28.2
Total	4,890,000	100.0

FIGURE IV

OXYGEN CONVERTER

Recently, there has been developed in Austria a type of operation fitted for the production of common-quality steels, namely, the Linz-type, top-fired oxygen converter. Insofar as ingot producers are concerned, this new tool is of immediate interest to them – in contrast to the long years involved in the arrival of the electric furnace. Though this youngster is but a few years old, two plants already are being built on this side of the water; one in the States, where the plan calls for the duplexing of the blown metal through electric furnaces; a second in Canada, where only a portion of the blown metal will be duplexed, the balance going directly to the mills.

By this time in 1955 we should have the results of the work of this lad who, still at grade school age-level, has stepped right into the tonnage ingot-production economy.

OXYGEN BLOWING IN THE ARC FURNACE

The third possibility for the electric furnace in the hot-metal field is still in the thinking stage. Assuming that this youngster from Linz has what it takes, is it or is it not possible to combine his efforts as an integral part of the electric furnace? With top-fired oxygen-blow on thirty-ton heats we know the volumetric expansion of the blow in relation to the dead-metal volume. We also know that the modern high-sideplate arc furnace has more than the required volume to accommodate the expansion. Top-charge, swing-aside-roof designs are being considered. The roof and superstructure would be rotated off the furnace, the hot metal introduced, and a second cover run over the furnace crucible to vent the fumes as well as the oxygen jets. The oxygen-jet cover is retracted from the furnace crucible upon completion of the blow, the normal roof and superstructure with the electrodes are swung back on, and the heat finished. Objections that would be raised to this plan are that the arc furnace would have to be built with interchangeable crucibles and that heavy cranes would be required on the furnace side for the removal and replacement of the lined crucibles. We can see no serious problem here, since any hot-metal transfer requires heavy cranes on the furnace side. From the furnace angle, we have for years been building arc furnaces with replaceable crucibles, with some installations of the swing-aside-roof design having as many as three furnace crucibles to each furnace superstructure. While this is presented here as being in the thinking stage as applied to 100-ton furnaces, it is interesting to note that it is already being done in smaller electric furnaces with 100 per cent hot-metal charges, top-blown with oxygen. What the cycle would be on crucible changes with 100-ton furnaces would be a matter of trial. We understand that they are getting 180 blows per lining with the thirty-ton Linz converters.

There may be other methods of approach for the arc furnace into the integrated plant, but it is quite apparent that two of these doorways will shortly be in everyday use and other methods remain for the future.

(Concluded on last page)

HEAT BALANCE OF ELECTRIC ARC FURNACE OPERATING ON A COLD-METAL CHARGE

	Kwhr Ton of Ingots	Per Cent
INPUT		
1. Power into transformers	525	100
OUTPUT		
2. Heat content of liquid steel	370	70.5
3. Heat content of slag	22	4.2
4. Refining reactions*	6	1.2
5. Heat content of waste gases	12	2.3
6. Heat extracted by cooling water	20	3.8
7. Electrical losses	40	7.6
8. Loss through walls, radiation, etc.	55	10.4
Total	525	100.0

FIGURE V

*Oxidation of silicon, manganese, and phosphorous by iron ore produces heat, but oxidation of carbon by the ore is an endothermic reaction. The net effect of all refining reaction is a loss of heat.

HOURLY PRODUCTION RATES ON TOP-CHARGED HIGH-POWERED ELECTRIC FURNACES—1953

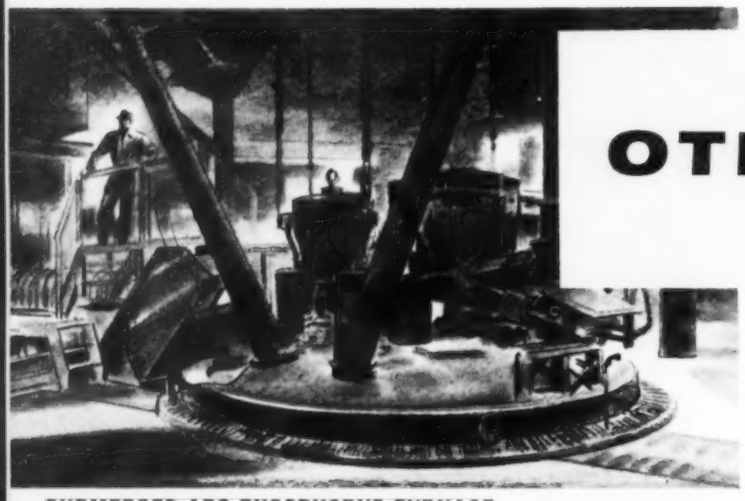
Size of Furnace	Size of Substation	Practice	Net Tons Produced Per Hour
15 ft.	12500 KVA	single slag	10.5
17 ft.	16000 KVA	" "	12.3
18 ft.	18750 KVA	" "	16.5
19 ft.	18000 KVA	" "	17.0
20 ft.	25000 KVA	" "	21.5
22 ft.	36000 KVA	" "	28.0

FIGURE VI

DIRECT-ARC FURNACE

AS W. B. WALLIS observes in this issue, the open-arc furnace has long been the preferred producer of alloy and stainless steels and is currently making giant strides as a competitive source of common steels for ingot tonnage and for even the largest castings.

Perhaps less well known to the steel industry at large are many other, power-hungry arc-furnace applications whose productive capacity and wide variety of products are felt throughout our entire economy.



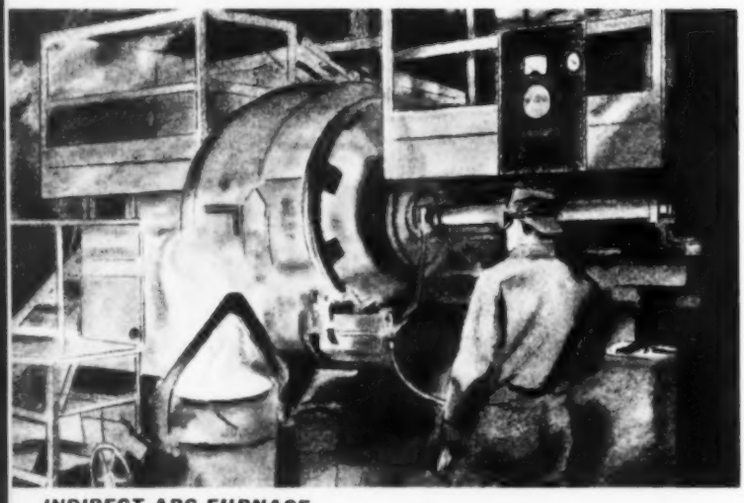
SUBMERGED-ARC PHOSPHORUS FURNACE

OTHER ELECTRIC

U. S. FERRO-ALLOY PRODUCTION—SMELTING POT OF THE WORLD

Iron and steel alloys and stainless steels are directly descended from a flourishing branch of the submerged-arc smelter — the distinguished family of ferro-alloys. U. S. producers literally scour the globe for alloy-bearing ores. Prodigious in its appetite for power and in the size of its installations, ferro-alloy production is heavily concentrated around areas of abundant, low-cost electrical "fuel."

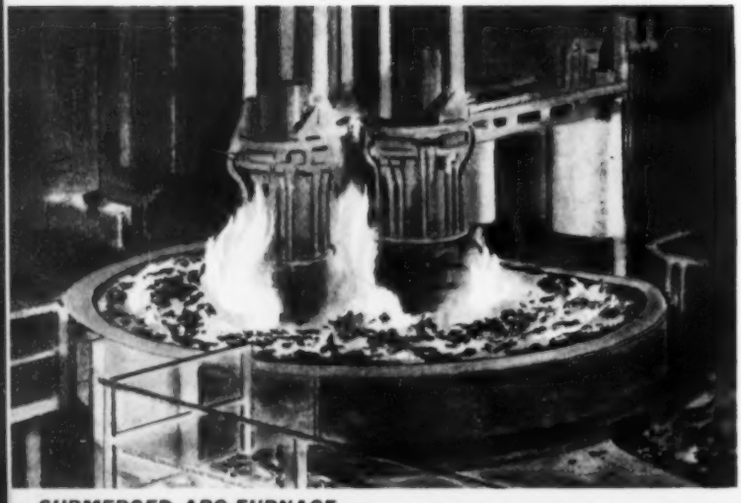
Focal points for the world's alloy-ores, these electric furnaces are, in turn, a source of alloying ingredients for ferrous and non-ferrous metals production all over the United States and abroad. The incandescence of the giant electrodes of the submerged-arc-type furnace is but a subdued fore-runner of the roaring open-arc furnace which will blend its products into mixtures of super-steels.



INDIRECT-ARC FURNACE

CALCIUM CARBIDE—LAMPLIGHTER, WELDER, CHEMICAL BUILDING BLOCK

The year: 1892. The place: Spray, North Carolina. The occasion: an abortive attempt to produce aluminum from its oxide in the "new" electric furnaces. Not aluminum, but a greyish, crystalline substance was the result of this pioneering effort. Attempting to quench



SUBMERGED-ARC FURNACE

this apparently worthless product with water, the furnaceman was rewarded with volumes of gas. Calcium carbide and acetylene were born!

Today, the submerged arc-furnace smelting of calcium carbide for acetylene production is a major industry — responsible for most of the acetylene gas used in welding, cutting and surfacing and, more recently, in the synthesis of vinyl and rubber plastics and acetic acid. Its possible future uses challenge the imagination.

today in this field. Once heavily concentrated in the TVA area, the leaps and bounds of its phenomenal growth are carrying phosphorus-furnace capacity into the power-rich, ore-heavy western U. S. and Florida. Used in vast quantities for foods, medicines, detergents and fertilizers, electric-furnace phosphorus has come a long way from the days of the strike-anywhere match . . . with more new uses in view. Who can say what new vistas of magic alchemy lie ahead?

ARC FURNACES AT WORK...

ABRASIVES AND REFRACTORIES—FORTUNES FROM CLAY AND KILOWATTS

To the ancients, all things were composed of four basic elements: earth, fire, air and water. Today, they would be amazed at the great *variety* of substances wrought by a conjunction of only two of their four elements — aluminous earth and the fire of the carbon arc. Given their basic tool in the Higgins arc furnace of 1904, abrasives manufacturers were quick to develop production of high melting-point materials for refractory applications, as well. Thus was born a myriad of new and useful products in the creative inferno of the electric arc.

PHOSPHORUS—ALWAYS SOMETHING NEW

All phosphorus is manufactured; it is never found by itself in Nature. Two generations ago, the entire world's production of elemental phosphorus did not exceed 400 tons. Today, this country uses ten times that amount for safety matches alone — a dim flicker in the light of an industry which is continually responding to the development of new processes and applications.

Unlike some of its earlier, easy victories over alternative methods of manufacture, the electric arc furnace competed vigorously with blast-furnace production of phosphorus for 27 years (1910-1937) before establishing the clear-cut advantage it holds

NON-FERROUS MELTING & REFINING—NEW LOOK AT AN OLD ART

Electric-furnace melting and refining of non-ferrous metals and their alloys are rapidly increasing. As in the fields of iron and steel production, electric-furnace methods of copper and aluminum melting and refining have had to face the task of winning general acceptance over historic, fuel-fired practices. Nevertheless, a growing percentage of all non-ferrous castings is poured from electric furnaces. In addition, a large share of this country's non-ferrous *refining* operations are now carried out in either direct or indirect-arc furnaces as contrasted with the universally accepted reverberatory-furnace procedure of a few years ago. Here, then, is another principal industry in which the electric arc furnace adds current events to a history almost as old as the written word.

IN SUCCEEDING ISSUES OF CARBON AND GRAPHITE NEWS...

Future issues of CARBON AND GRAPHITE NEWS will bring you contributions from recognized authorities among furnace and equipment manufacturers, consultants, metallurgists and producers.

Watch For Them...
And Let's Have Your Comments!

There is no question that, just as the electric furnace has at long last arrived in the cold-metal field, it will be very much in the picture in future integrated plants.

FLEXIBILITY

Finally, the electric furnace is most flexible. It is not limited to continuous operation once it has been put under fire. It can be shut down and restarted at will. It is ideally adapted to the forty-hour week and requires no special arrangement for crews over holidays.

QUALITY CONTROL AND THE NEW MARKET

We have, for too long a time, enjoyed a seller's market; in fact, it has been the longest seller's market of any period in the steel industry. We are now entering a buyer's market which, after all, is but a return to normalcy. Many of us will have to refurbish some of the tools in selling our products that were in everyday use twenty to twenty-five years ago. Unfortunately, those sales tools that we used so well in the period of the '30s are just not going to work in the buyer's market ahead. The buyer in the saddle is, of course, going to insist upon quality as he always has. He is going to draw his specifications a little finer due to the expansion of metallurgical knowledge within the industry, but one factor that has got to be kept in mind is that he has at hand many new tools for the checking of these factors of quality in specification that were not heretofore available.

Looking forward, we can see no relaxation in specifications on qualities of even the most common steels. The electric furnace is the tool that can best fulfill the requirements of this future buyers' market demand.

ELECTRIC FURNACES IN THE FOUNDRY

To turn for the moment to the foundry industry in the United States, the electric furnace has long been accepted for the production of small castings. The vast majority of the jobbing steel foundries in the United States are so operating. In this branch of the industry, acceleration (MV^2) was not too high for the youngster to get aboard years ago.

The field of large-casting production presents a problem for the electric furnace. While it is just as true that the steel foundryman cannot produce molten metal with his open-hearth furnace for as little money as he can with an arc furnace, he has further problems to consider. There has been for a long time a conviction on the part of foundrymen that on large castings they could not make as high-quality castings with electric furnaces as they could with open-hearths. This conviction has been hard to disprove for the very simple reason that we have no large electric furnaces making large castings in steel foundries in the United States. However, foundrymen who do have furnaces making relatively small twenty-five-ton heats in foundries have satisfied themselves on this one point.

There still remains another problem. If the foundryman matches his open-hearth, size for size, with an arc furnace and, per se, the size of the largest casting, he is then faced with the fact that he has twice as much metal production from the electric as he has been obtaining from the same size open-hearth. In other words, more metal than he can use.

Recently, in the production of large castings, some foundrymen in this country, as in Europe, have been making these large castings in sections, machining them, shipping them to site, and there welding them into the large integral unit desired. This practice is relatively new and, once developed, has many advantages. First, it cuts down tremendously the flask expense and handling expense, both in the foundry and the machine shop, and cuts down the cost of special transport to site. This practice, fully developed, will enable the foundryman – where he is using a 100 ton open-hearth – to apply a fifty-ton electric for not only the production required but also for the largest-size casting needed.

THE FUTURE

There was a time at the end of World War II when we felt we had arrived at the end of the road; that we had installed more electric furnaces than the industry could absorb and that our activities would henceforth be limited to resale and relocation of equipment that had been applied to war use. The expansion period between 1949 and 1953 was, therefore, a most welcome and highly exhilarating rebuttal to that feeling.

The electric furnace now has been with us forty-eight years–years of progress that was slow because a deep and firm foundation of proven performance was being built. If one could project the data over the next forty-eight-year period, to the year 2002 – perhaps open-hearths might be hard to find.

References

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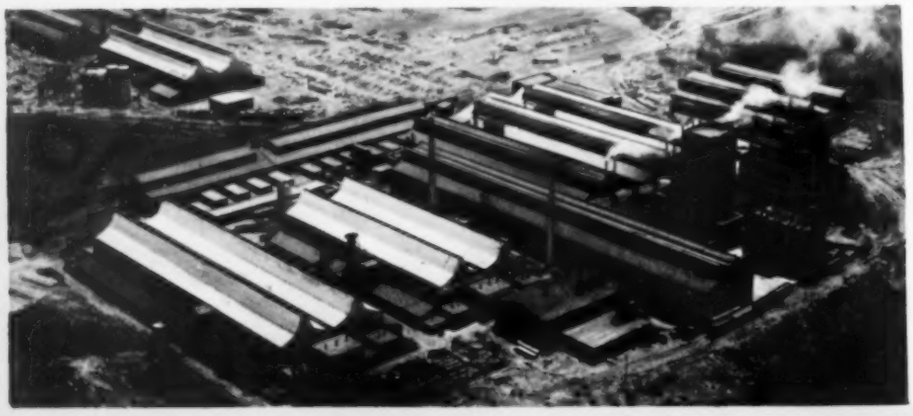
3. King, C. D., *Steelmaking Processes – Some Future Prospects.* Howe Memorial Lecture, New York Meeting, A. I. M. E., February, 1954. Published in Journal of Metals, April, 1954.
4. Phelps, H. F., Consulting Engineer.

WILLIAM B. WALLIS *graduated from The Pennsylvania State College in 1911 and first became interested in arc furnaces in 1913 while working for a public utility company in western Pennsylvania. By 1915, he had gone actively into the building of arc furnaces and has continued that work to date. By 1936 he was concerned with the introduction of arc furnaces into the copper industry and in 1937-38 was consulting engineer on the first large six-electrode smelting furnace installed in Europe. His major activity has been in building electrical arc furnaces for the steel industry.*



Columbia, Tennessee Works of National Carbon Company, a Division of Union Carbide and Carbon Corporation

This is but one of the five plants of the Company devoted to the manufacture of carbon and graphite electric furnace electrodes. Plant additions in the last five years alone have more than doubled graphite electrode capacity.

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Dust, dirt and smoke are the sworn enemies of mill motors and switching gear. That's why clean air for motor room ventilation is so vital to continuous operation and low maintenance costs. For such applications, where only super-clean air will suffice, AAF offers a choice of two high efficiency electronic precipitators.

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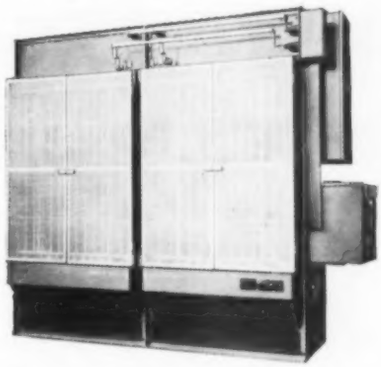

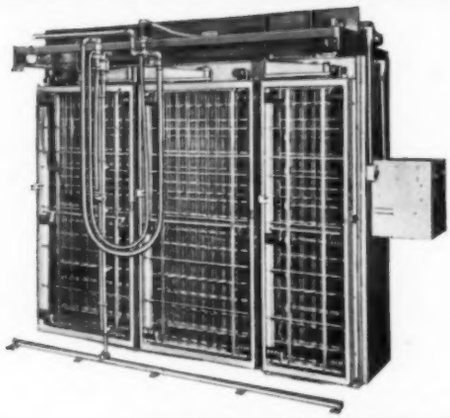

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A stationary, plate-type electronic precipitator which, with the addition of the Type H Washer, provides push-button control of complete cleaning operation. Both washing and re-oiling of collector plates are fully automatic after starting button is pushed. If manual cleaning is preferred, collector plates may be washed and re-oiled in place or easily removed for inspection. Ask for Bulletin No. 252.

AND BLAST FURNACE OPERATION

The pressure blowers on which blast furnaces depend for their air supply have a spot that is vulnerable to dust and dirt. It's the impeller blades. If the intake air is not thoroughly cleaned of these particles, they act as an abrasive on the blades, causing rapid wear and eventual shutdown for repairs. One air filter—the AAF Multi-Duty—has proved an outstanding success in this service and scores of these units are today serving the steel industry throughout the world.

AAF Multi-Duty

An automatic, self-cleaning filter designed for handling heavy dust loads. Continuous, automatic cleaning of the filter curtain assures both constant efficiency and uniform air delivery regardless of the dust load. Its operating resistance remains fixed, when once established for a given dust concentration and requires no attention other than periodic inspection and removal of sludge at regular intervals. Ask for Bulletin No. 241.

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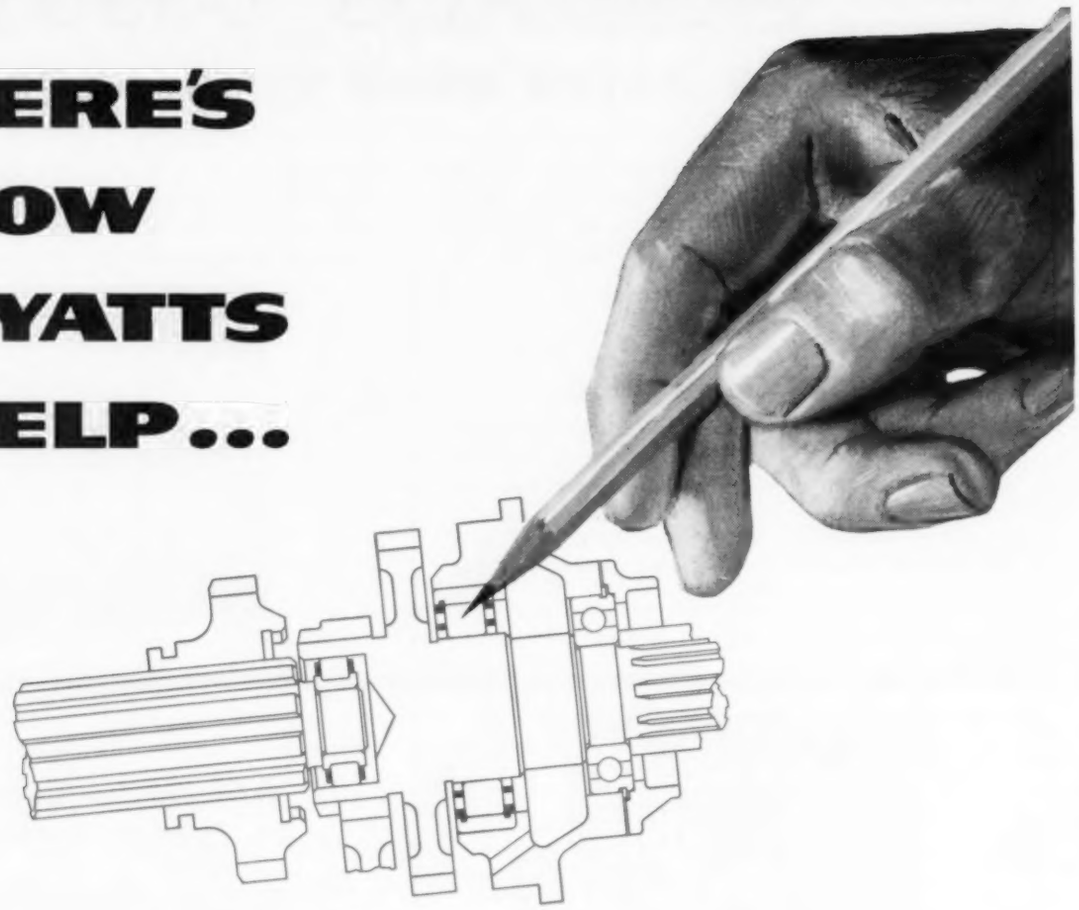
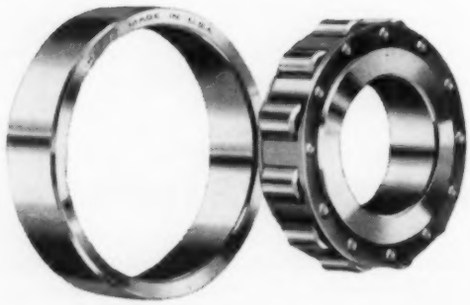
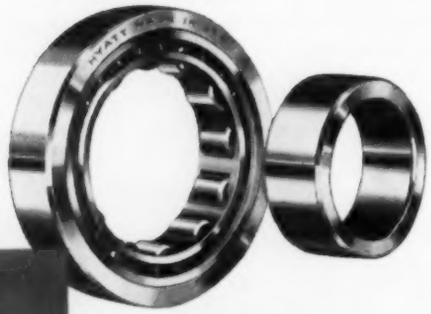
HERE'S HOW HYATTS HELP...







Sometimes a fraction of an inch is the difference between a simple design modification and costly re-tooling. And the engineer who is thoroughly familiar with Hyatt Roller Bearings will know a lot about how to save those fractions. He'll know, for example, that to gain greater shaft rigidity with the same size housing, he need only check his Hyatt catalog for a separable inner race type of bearing. This type—available in a wide range of sizes—may be applied with the rollers operating directly upon the surface of a suitably hardened and ground shaft. Thus, a larger-diameter shaft may be used without sacrificing bearing capacity, or a larger-size bearing may be used without changing the size of the shaft. For a copy of Hyatt's latest catalog, No. 150, write to Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

Personnel News...

Alfred E. Kadell has been elected senior vice president of Great Lakes Steel Corp., and **Charles E. Carr** has been appointed to succeed him as general superintendent of the Weirton Steel Co. Mr. Kadell has been affiliated with National Steel since 1925 when he began service with the Weirton Steel Co. as assistant to the chief metallurgist. He remained in the metallurgical department until 1929 when he became night superintendent of the Weirton Tin Mill. A year later he was promoted to assistant manager. In 1936 he was appointed manager of the company's Steubenville plant and in 1944 became manager of the Weirton Tin Mill. Mr. Kadell became general superintendent of Weirton Steel Co. in 1953. Mr. Carr, who was manager of the Weirton works began service with the company as a second helper in the open hearth department in 1921 and advanced through various positions to manager of that department in 1952. Other promotions at Weirton include: **W. D. Spaulding,** formerly superintendent of blast furnaces and coke plant, to manager of the steel works. **R. W. Grace,** the former superintendent of the blooming mills, to assistant manager of the steel works. **A. R. Benbow,** formerly assistant superintendent of the blooming mills, has been promoted to superintendent. **R. B. Allard,** assistant to the manager of the Weirton steel works, has been appointed manager of the Great Lakes steel works.

L. J. Rohl was appointed to the newly created position of chief metallurgical engineer of U.S. Steel Corp. In this new position, Mr. Rohl will coordinate the metallurgical activities of all divisions of U.S. Steel, to the end that the highest quality products will be manufactured. At the same time it was announced that **R. W. Simon** has been named to succeed Mr. Rohl as chief metallurgical engineer, operations — steel. Mr. Rohl joined U.S. Steel at South Works, Chicago, Ill., in 1917. He advanced through the positions of product metallurgist, assistant superintendent of alloy production, assistant superintendent of the production department, and superintendent of production. In 1933, he became assistant to the general superintendent of South Works and later that year he was appointed assistant manager of the Chicago District metallurgical division. In 1943, he was made manager of this division and was promoted to the position of assistant chief metallurgical engineer in 1947. Later that year he was made chief metallurgical engineer, operations — steel. In 1953, Mr. Rohl spent several months in Europe as a government consultant for the European Steel Industry. Mr. Simon joined U.S. Steel in 1927 as a metallurgical assistant at Homestead Works. He served in various metallurgical and administrative capacities at Duquesne and Youngstown Works until he was appointed as a metallurgist to the Pittsburgh general office metallurgical staff in 1935. In 1939, he was made assistant manager of the Pittsburgh District metallurgical division and was appointed manager of the division in 1942. In 1947, he was made assistant chief metallurgical engineer, operations — steel.

Lawrence L. Hall has been appointed superintendent of hot strip mills at Republic Steel Corp's., Warren Ohio, plant. Mr. Hall succeeds **Emil J. McCauley** who has been transferred to Cleveland. At the same time, **Harold E. Freeland** was appointed assistant superintendent of the Warren hot strip mills. Mr. Hall started with Trumbull Steel Co., Republic's predecessor company in Warren, in 1927. In 1936 he was named a turn foreman in the hot strip mills and was promoted to assistant superintendent in 1946. Mr. Freeland joined Republic at Warren in 1932. After service in the coke plant, blast furnace and open hearth departments he transferred to the hot strip mills in 1935.

Joseph C. Henry, Jr. is the new superintendent of the refractories and fuel department at Lukens Steel Co. He succeeds **Russell R. Fayles** who a year ago was made staff assistant to the manager of fabrication, by-products division. Mr. Henry joined Lukens in the open hearth department as an engineer in 1942. In successive promotions he was advanced to assistant fuel engineer and fuel engineer in the open hearth. He was named fuel supervisor in the department he now heads in 1950 and assistant superintendent in 1951.

Austin J. Paddock was appointed vice-president in charge of contracting for U. S. Steel Corp's., American Bridge Division. At the same time appointment of **R. Bruce Hunter** as vice president in charge of

ALFRED E. KADELL

CHARLES E. CARR

L. J. ROHL

R. W. SIMON

manufacturing operations was announced. Mr. Paddock began working with American Bridge as a timekeeper in the erecting department in 1929. In 1934, he was appointed assistant to manager of the bridge company's Elmira plant and in 1937, advanced to plant manager. In 1941, he was transferred to the Gary plant where he was manager for five years. In 1946 Mr. Paddock was appointed vice president in charge of manufacturing operations, the position he has held until his present appointment. Mr. Hunter began his working career with American Bridge in 1912 as a templet maker at the Gary, Ind., plant and a year later was promoted to inspector. In 1918 Mr. Hunter was promoted to foreman at the Gary plant. In 1947 he was named plant manager, the position he held until his recent appointment.

Raymond Ulbrich has been named superintendent of mechanical maintenance at Kaiser Steel Corp. Mr.

RAYMOND ULBRICH

Ulbrich came to Kaiser in 1948 after 25 years with the National Supply Co. Since then he has been assistant superintendent of mechanical maintenance.

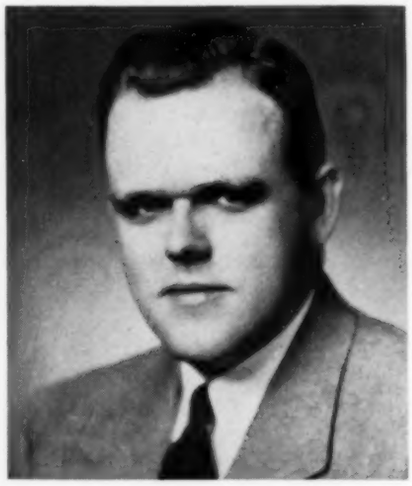
J. W. McMullen was named vice president in charge of engineering of the Lombard Corp., Youngstown, Ohio. **A. P. Sqambati** was made chief engineer of the company.

John W. McAllister was appointed administrative assistant to the president of Colorado Fuel and Iron Corp. Mr. McAllister has been associated with CF&I for over 30 years. He was first employed in 1923 as a machinist helper in the coal mines of the company in Southern Colo. He was later transferred to the fuel and steel operating departments at Pueblo, then to the general offices of the corporation in Denver in 1930.

William C. Buell, Jr. has recently retired as a member of the consulting staff of Arthur G. McKee Co. His services, however, will be available for consultation on steel ingot production work.

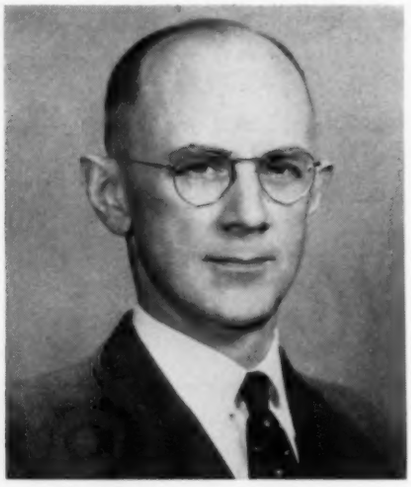
James C. Keney has been named to the sales staff of the Chicago district office of the E. W. Bliss Co. Mr. Keney was formerly engaged in field service and erection of Bliss equipment. Prior to joining Bliss he was with Babcock Printing Press Corp. and Republic Steel Corp.

William H. Feathers has been named vice president and general manager of industrial products of National



WILLIAM H. FEATHERS

Carbon Co. It was announced at the same time that **Walter A. Steiner** has been appointed vice president in charge of development.



WALTER A. STEINER

Frank N. Long has been named superintendent of the newly-created Zincgrip department at Armco Steel Corp., Ashland, Ky., Works. Since 1944 he has served as general foreman of the galvanizing department.

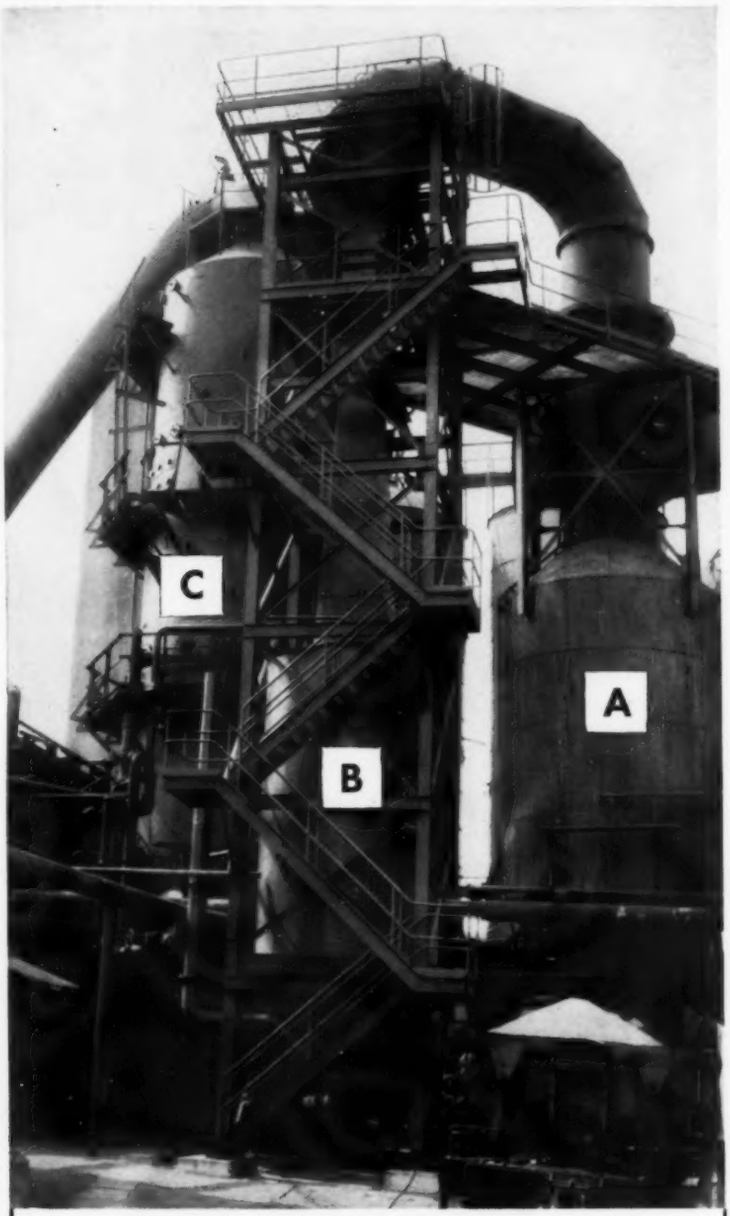
John V. Boardman has joined the Green River Steel Corp. as general superintendent. Mr. Boardman was formerly at Worth Steel Co., Claymont, Del., as general superintendent and upon the purchase of Worth by the Colorado Fuel & Iron Co., served in the capacity of assistant works manager and works manager. Before going to Worth in 1946, he was with Jones & Laughlin Steel Corp. in the rolling mill department.

Lawrence Young, chief electrician of the Kaiser Steel plant, has been appointed superintendent of mechanical shops. In his new position Mr. Young will

When it's time to rebuild...

it's time for

P-A



When your blast furnace is to be shut down for repairs or rebuilding . . . that's a particularly good opportunity to install a Chemico P-A Venturi Gas Scrubber.

The P-A Scrubber will put your full top pressure to work cleaning your blast furnace gas . . . and will do it with surprisingly low water consumption, thus minimizing your thickener requirements.

A P-A Scrubber costs little to buy, little to install, and little to maintain. Also, it fits into small space and requires no attention. For most installations *no further cleaning is required.*

Units are available for capacities ranging up to 150,000 cfm. Phone (MUrray Hill 8-7400) or write our P-A Sales Department for complete information and ask for our bulletin M-102 on P-A Gas Scrubbers. At your request, our technical representative will come to you with full details.

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A Unit of American Cyanamid Company

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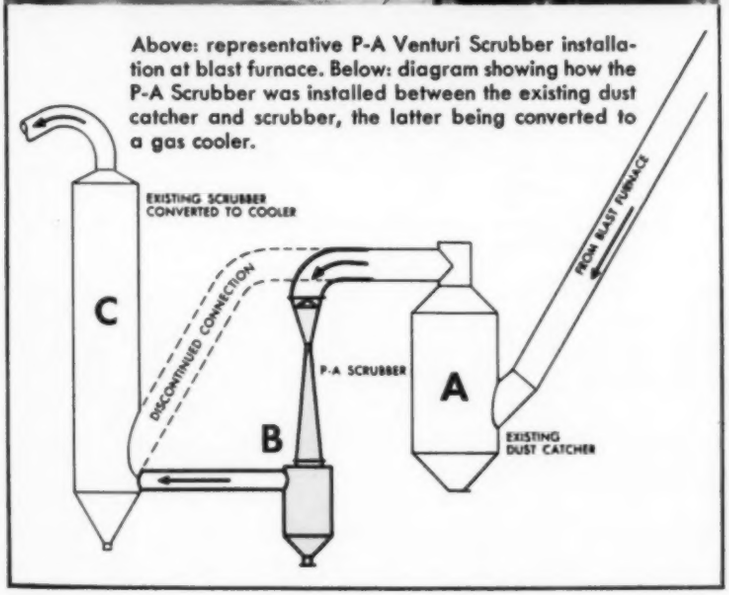
Above: representative P-A Venturi Scrubber installation at blast furnace. Below: diagram showing how the P-A Scrubber was installed between the existing dust catcher and scrubber, the latter being converted to a gas cooler.



CHEMICO

P-A

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GAS SCRUBBERS

Low Cost

Bearing Insurance

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Rolling Mill

Lube Oil Purifier

You can have 'round the clock protection against water and abrasion damage to rolling mill bearings—simply by putting a Sharples Lube Oil Purifier into action. At low cost, it continuously removes all water, tank scale, rust and other contaminants from the oil. You get full protection plus a bonus of peak lubricating efficiency at all times.

A Sharples Lube Oil Purifier takes only ten minutes to clean . . . is practically maintenance free. It's really cheap "insurance" that pays for itself in the first few months of operation.

Write for Bulletin 1264.

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be responsible for all mechanical shops and field crews. He came to Kaiser Steel in 1942 to perform electrical construction. Since then he has been foreman of the

LAWRENCE YOUNG

electrical shop, general electrical foreman of the tin plate mill and chief electrician.

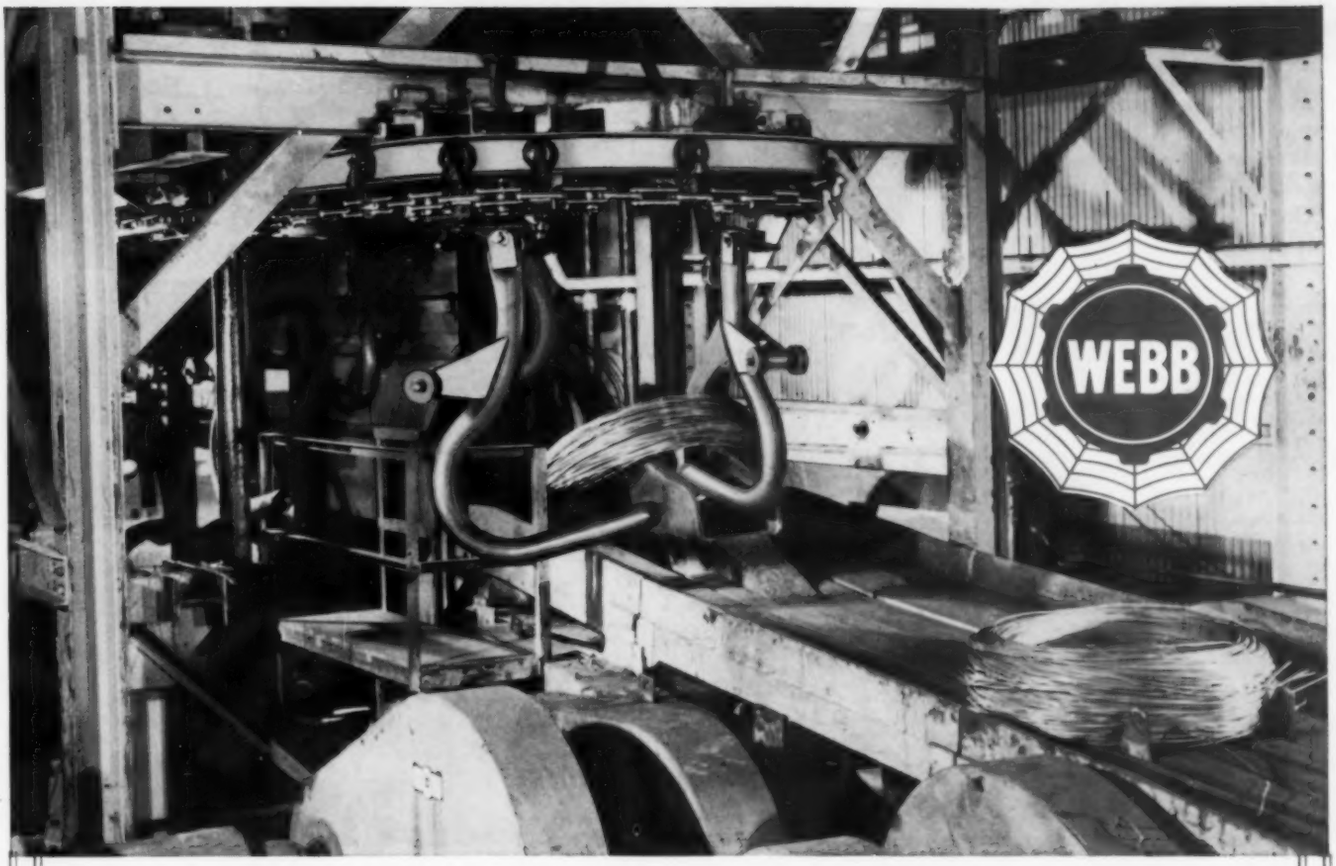
Howard H. Casey was appointed director of engineering of the Midvale Co. Mr. Casey, formerly general sales manager, will head the company's engineering, metallurgical and research staff.

Carl E. Schlossnagel has been appointed superintendent of production planning at the Duquesne Works

CARL E. SCHLOSSNAGEL

of U. S. Steel Corp. He was formerly assistant superintendent of that department.

Edward R. Engbrecht has been appointed shop superintendent at the Trenton, N. J. plant of U. S. Steel Corp., American Bridge Division. He succeeds **Lester J. Larison,** who has been named plant manager of the division's Roanoke, Va., plant. Mr. Larison has been shop superintendent since 1943 at the Trenton plant. Mr. Engbrecht began with U. S. Steel at its South Works as an inspector in 1934, and began with American Bridge at its Gary, Ind., plant in 1943 as a sub-foreman. Two years later, he was made foreman—automatic welding and special work. In 1953, he was



Jones & Laughlin Hot Rod-Coils Handled *Automatically* By Webb Conveyors

Hot from the laying or pouring reels, these coils of rod steel are handled automatically by Webb Conveyors throughout their trip to storage or shipping in the Jones & Laughlin Rod Mill at Aliquippa, Pa.

Rod coils are approximately 46" in diameter and weigh 600 pounds—4 of these hot coils are handled by Webb Conveyors every minute without a hand touching them. Single and double-strand drag conveyors and overhead trolley conveyors are employed in this highly integrated materials handling system.

Typical of the smooth automation and ingenious transfer of coils from one conveyor to another is the illustrated lifting of coils by a cam actuated bobber at the end of the drag conveyor, and automatic insertion of trolley conveyor hook into rod coils. This operation is accomplished without distortion of coils, and in spite of loose rod ends.

Ask a Webb engineer to look at your tough handling problems—his experience and engineering knowledge are waiting your call.

Additional Webb Services—Through its subsidiaries, Control Engineering and Webb Forging Co., the Jervis B. Webb Co. designs and manufactures electronic and electrical controls for conveyors, machine tools, etc. Also quality drop forgings.

JERVIS B. WEBB CO.
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Send for fully illustrated catalog that provides complete information on Webb conveyors

FACTORIES: DETROIT • LOS ANGELES • HAMILTON, ONTARIO
OFFICES AND REPRESENTATIVES THROUGHOUT THE WORLD

made foreman—fitting and riveting, and in February of this year was made foreman—punching of beam and column work.

John G. Zimmerman was appointed manager — applied research and development of U. S. Steel Corp. Other appointments include **Robert B. Mears,** director — applied research laboratory, who will be in charge of the applied research and development at U. S. Steel's new research center now under construction at Monroeville, Pa., **Saylor C. Snyder,** director — product development, **David L. McBride,** director—metallurgical process development, and **Charles A. Bishop,** director — chemical process and chemical engineering development.

H. B. Stallings was named to head up electro clutch sales of I-T-E Circuit Breaker Co. Mr. Stallings has had over 20 years' experience in the steel, machine tool

H. B. STALLINGS

and other associated industries. He will supervise application of the Electro Clutch to the iron and steel industries.

William E. Grover has been appointed chief erection engineer of Surface Combustion Corp. Mr. Grover will supervise all field erection work for the company's industrial furnace division, replacing **H. L. Bergman**

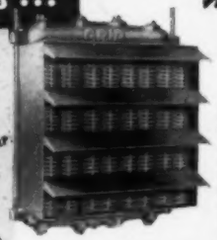
WILLIAM E. GROVER

who recently died. He has been associated with the corporation since 1935. For practically this entire period, he has been engaged in field erection work. Since 1946, he has been district engineer for the company in Detroit.

Wallace E. Powell, formerly a control systems engineer for Jones & Laughlin Steel Corp., has been named president of Control Products Co., Inc., Oakdale, Pa. The new company will design and manufacture automatic control systems for the steel, non-ferrous,

THE NATION'S STEEL MILLS and Leading Industries...

Use GRID Unit Heaters ... and here's why ...



Maintenance cost conscious management men turn to GRID for relief from the continuous expense of heating failures experienced with ordinary unit heaters. GRID service records established over years of operation in heavy industry prove GRID installations will provide adequate comfortable heat without constant service care. GRID Units installed in 1929 are still operating today . . . the only attention needed has been an occasional oiling of the motor. No ordinary unit heater can approach this record.

GRID's All-Cast construction having similar metals in contact with steam prevents electrolytic corrosion — GRID's ability to withstand steam pressures up to 250# P.S.I. — GRID's low outlet temperatures, proper fan sizes and motor speeds assure delivery of warm comfortable air in ample volume, directly to the spot where it is needed. These are the reasons why the nation's leading industries use GRID.

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Representatives in all principal cities.

Johns-Manville announces the development of new **SIL-O-CEL 16L** *Insulating Fire Brick . . .*

Lompoc, California, where Johns-Manville mines and processes diatomaceous silica insulating materials

Combines outstanding physical and thermal properties for furnace service to 1600F

Check these properties of SIL-O-CEL 16L

Maximum service temperature	1600F, back-up or exposed
Approximate density	33-35 lb per cu ft
Transverse strength	60 psi
Cold crushing strength	350 psi
Linear shrinkage	0.7 percent at 1600F
Reversible thermal expansion	less than 0.1 percent at 1600F
Thermal conductivity (Btu in. per sq ft per F per hr at indicated mean temperatures)	0.92 at 500F 1.07 at 1000F 1.22 at 1500F

1—has less than 0.1% reversible thermal expansion at 1600F

2—provides high load-bearing strength

3—for direct exposure or back-up service

Here is a new development of Johns-Manville insulation and refractory research. Its exceptional characteristics provide important savings in furnace construction. Made of diatomaceous silica, Sil-O-Cel* 16L Insulating Brick is light in weight . . . has low thermal conductivity . . . high structural strength. And where furnace linings are subjected to severe heat shock or where high load-bearing properties are needed, Sil-O-Cel 16L offers outstanding performance.

Sil-O-Cel 16L is now available. Samples will be sent on request. Also available without obligation is Booklet IN-115A, which describes Sil-O-Cel 16L and other J-M Insulating Brick and Insulating Fire Brick for service to 3000F. Write Johns-Manville, Box 60, New York 16, N.Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Sil-O-Cel is a Johns-Manville registered trade mark

Replaces SIL-O-CEL Natural Brick

The development of Sil-O-Cel 16L Insulating Brick has resulted in the discontinuance of Sil-O-Cel Natural Brick. The outstanding properties of Sil-O-Cel 16L make it the ideal replacement for Sil-O-Cel Natural Brick for back-up use. In addition, the properties of Sil-O-Cel 16L Brick extend its use to exposed service applications.

Johns-Manville *FIRST IN* INSULATION

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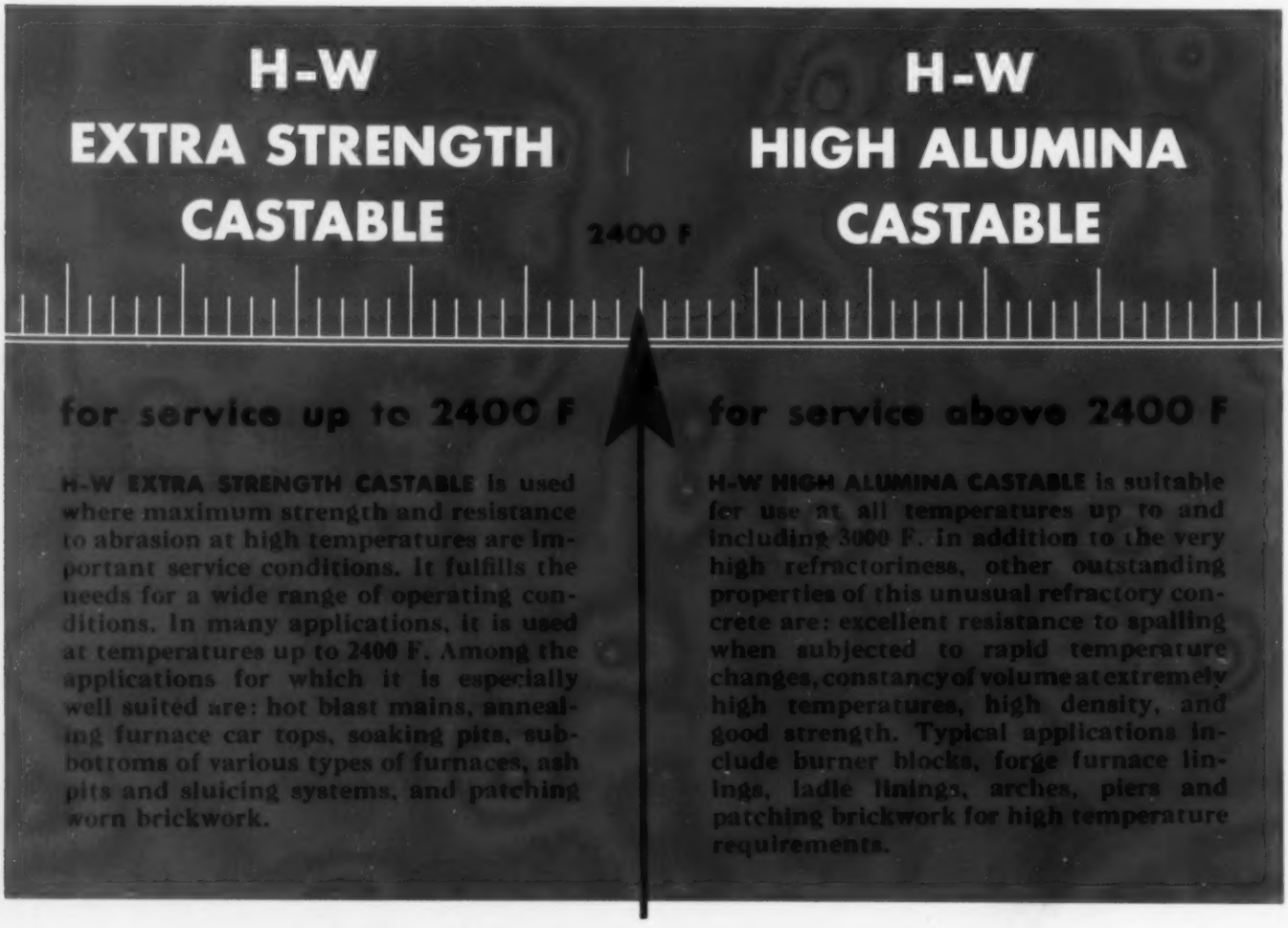
THESE TWO HARBISON-WALKER CASTABLE REFRACTORIES

to serve you better . . .
for a wide range of operating conditions


H-W
EXTRA STRENGTH
CASTABLE
2400 F
H-W
HIGH ALUMINA
CASTABLE
for service up to 2400 F
H-W EXTRA STRENGTH CASTABLE is used where maximum strength and resistance to abrasion at high temperatures are important service conditions. It fulfills the needs for a wide range of operating conditions. In many applications, it is used at temperatures up to 2400 F. Among the applications for which it is especially well suited are: hot blast mains, annealing furnace car tops, soaking pits, subbottoms of various types of furnaces, ash pits and sluicing systems, and patching worn brickwork.
for service above 2400 F
H-W HIGH ALUMINA CASTABLE is suitable for use at all temperatures up to and including 3000 F. In addition to the very high refractoriness, other outstanding properties of this unusual refractory concrete are: excellent resistance to spalling when subjected to rapid temperature changes, constancy of volume at extremely high temperatures, high density, and good strength. Typical applications include burner blocks, forge furnace linings, ladle linings, arches, piers and patching brickwork for high temperature requirements.

These refractory castables can be mixed and poured like concrete or can be applied by means of various types of air guns.

Harbison-Walker castable refractories are available in all the various classes, having the most desirable combinations of properties for particular requirements, such as adequate refractoriness, strength, insulating value, resistance to thermal shock and the corrosive action of slags and fluxes.

Please write us for detailed information and recommendations for specific applications.

HARBISON-WALKER REFRACTORIES COMPANY
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electrical, oil, chemical and other process industries. In addition to designing and installing automatic sequence control panels for existing industrial operations, Control

WALLACE E. POWELL

Products Co. will also build control components for all types of new, original equipment.

John Upton, Jr. has been appointed general manager of the Hallden Machine Co.

Paul A. Pierce has been appointed manager of operations for Continental Foundry & Machine Co., East Chicago, Ind. Formerly manager of foundries, Mr. Pierce joined the company in 1920 as a pattern maker. Prior to that he was in the pattern department of Inland Steel Co.

Obituaries

W. Francis Scanlan, superintendent of maintenance, Alan Wood Steel Co., Conshohocken, Pa., died July 15. Mr. Scanlan had been with the company for 37 years. He was very active in the affairs of the Philadelphia Section of AISE for some years.

Frank P. Dahlstrom died July 15. Mr. Dahlstrom has been well known in the steel industry as an inventor and consultant. He was one of the developers of the precision flooded-lubricated oil film bearing extensively used in rolling mills, and in the past few years has been very active in developing computing machines for rolling mill calculations.

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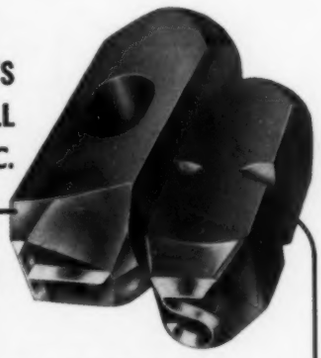
Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

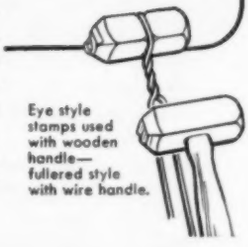
STAMCO, Inc., New Bremen, Ohio

FOR **STAMPING**
HOT OR COLD BILLETS
INGOTS • SLABS • MILL
ROLLS • END CUTS • *ETC.*



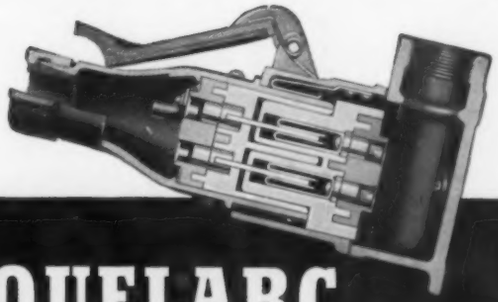
Mecco **SAFETY**
EYE and FULLERED FORGING STAMPS

Furnished with one or more characters, these stamps have extra large shanks engraved with heavy bevels to withstand roughest service. Eye forgings available in single and double end styles. Non-spalling and non-mushrooming features of both styles are important safety factors.



Eye style stamps used with wooden handle—fullered style with wire handle.

Mecco SAFETY MARKING TOOLS **M.E.CUNNINGHAM CO.**
1041 CHATEAU STREET, PITTSBURGH 33, PA.



QUELARC The Circuit-Breaking Plugs and Receptacles . . . Ratings up to 200 AMPERES

The exclusive QuelArc construction provides exceptional protection to contacts, for safe use as current rupturing devices. Unique partitioned insulation provides extra long distance between contacts and between contacts and ground. Insulating chambers completely enclose all contacts and form an arc-trapping space. Galvanized cast metal housings, bakelite insulation and individually renewable contacts insure long service life.

QuelArc plugs and receptacles are available in a complete range of styles, 2, 3 and 4 pole types—grounded through shell or extra pole. Housings with threaded cap, plain cap or hinged spring door. Ratings 20, 30, 60, 100 and 200 amperes, 250 volts DC, 600 volts AC. Consult your Pylet Catalog 1100, Bul. 1140-2 for complete listings.

SINCE 1897
CONDUIT FITTINGS • FLOODLIGHTS
THE PYLE-NATIONAL COMPANY
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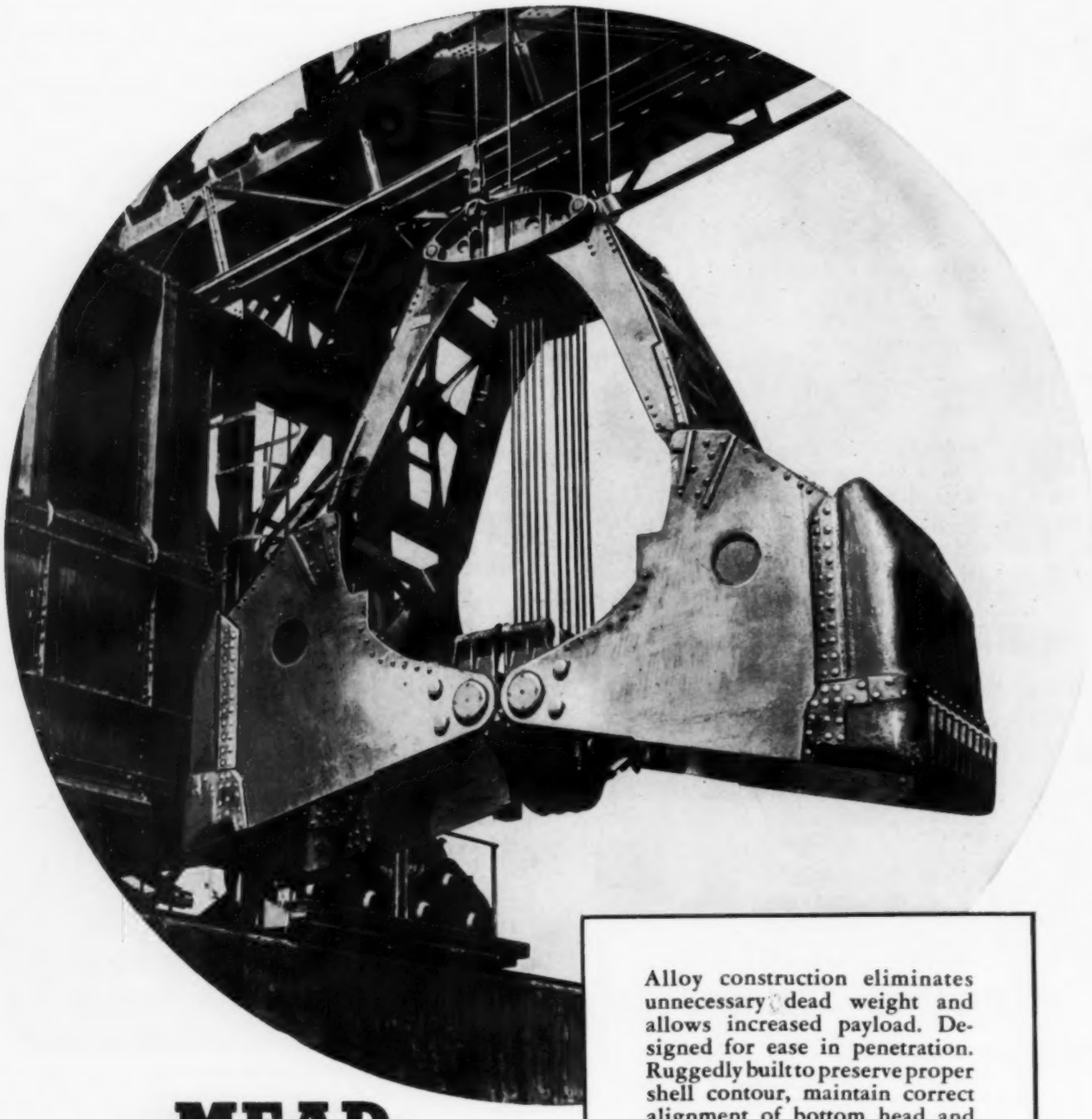
MEAD-MORRISON Ore Buckets



Alloy construction eliminates unnecessary dead weight and allows increased payload. Designed for ease in penetration. Ruggedly built to preserve proper shell contour, maintain correct alignment of bottom head and shell and withstand operating abuse.

Designs to operate at ends of lines and bight of line in a range of sizes. Also clean-up grabs.

Write for full information.

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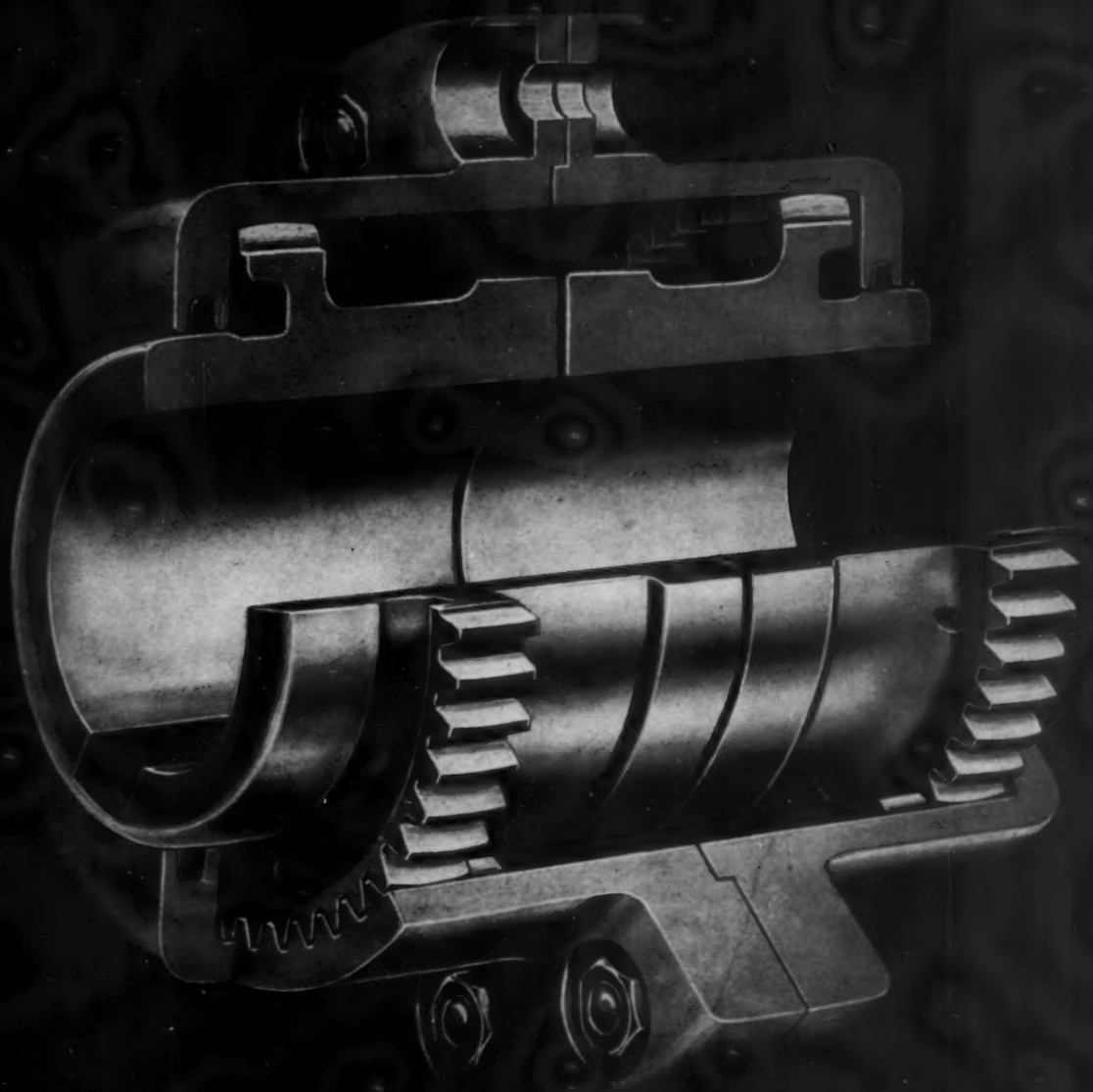
Also builders of coal and ore bridges, bulk material unloaders, pile hammers, and specially designed machinery

MK 808

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

ELLIOTT CROCKER-WHEELER 600 SERIES MILL MOTORS

This is one of three 450-ton hot metal ladle cranes servicing nine furnaces in the open hearth department of U. S. Steel's Fairless Works. They were designed and built by the Alliance Machine Company of Alliance, Ohio and are the largest cranes ever built for this type of operation.

The various hoist, trolley and bridge motions of these mechanical giants demand rugged, dependable motors that can stand the gaff of peak loads and heavy current changes. Elliott C-W 600 series mill motors have proven a natural for the job. Each crane employs eight of these motors, totalling nearly 1300 hp. They range in size from the two 265-hp motors lifting the 450-ton main hoist (through a synchronized worm gear), to a 65-hp motor operating the second auxiliary hoist.

For complete details on these motors, call your local Elliott field engineer, or write for the Mill Motor Bulletin to Elliott Company, Jeannette, Pa.

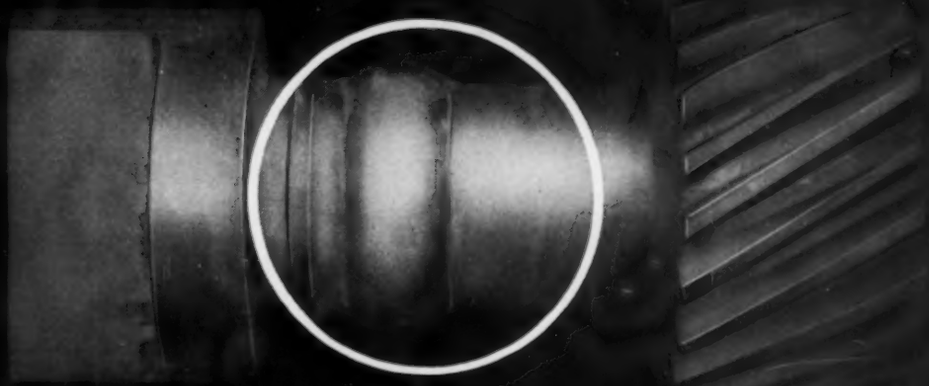
ELLIOTT Company

W4-6

TURBINE-GENERATORS TURBINES MOTORS GENERATORS DEAERATING HEATERS EJECTORS CONDENSERS COMPRESSORS TURBOCHARGERS TUBE CLEANERS STRAINERS

Here's where

THERMIT WELDING STOPPED THE CLOCK!



Weeks of idle time saved in returning pinion to duty...

When a piece of vital equipment breaks down, Thermit Welding stops the clock on idle time — enables quick, economical repairs on a variety of parts. Only a *minimum* of technical skill is required.

See the time-saving repair made on the 48" mill pinion shown above. The 28" neck was Thermit welded — and the pinion was back in operation *weeks* before a replacement could be obtained.

WAITING FOR REPLACEMENT PARTS COSTS TIME AND MONEY!

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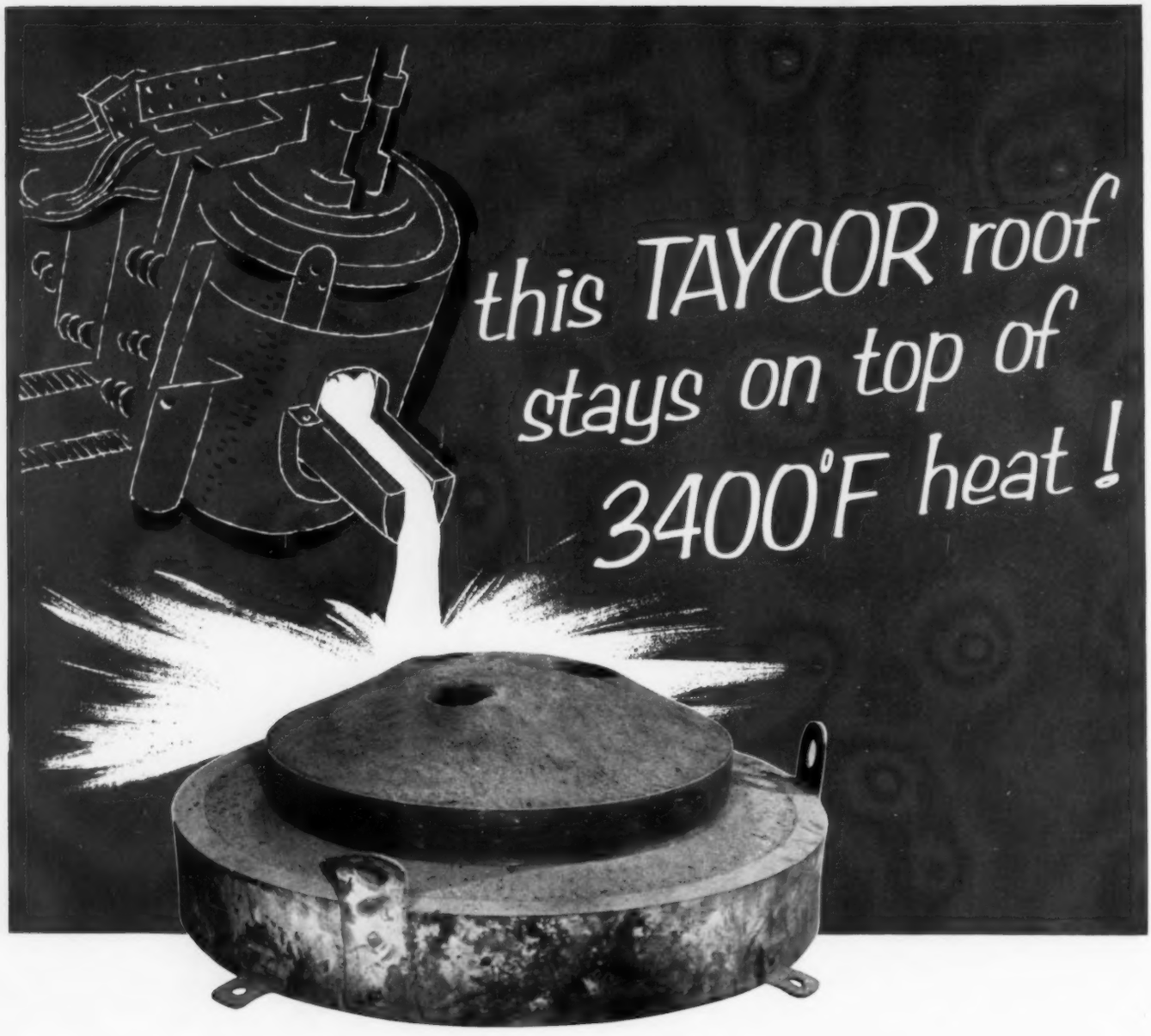

This monolithic roof of TAYCOR Ramming Mix is for a 1000-lb. basic direct arc furnace used to melt a variety of heat-resistant alloys. Furnace operates 16 hours daily at temperatures as high as 3400° F. Extensive tests have been conducted to improve roof life for this severe application. The result of these tests proved TAYCOR Ramming Mix lasted *two to three times longer* than any other refractory. TAYCOR roof life varies from a low of 200 heats to a 900-heat record high, depending upon the alloy being melted.

TAYCOR is our trade name for Corundum-base super-refractory brick, special shapes, cements, patches and ramming mixes. The outstanding properties of TAYCOR are exceptional refractoriness, high hot load strength, superior resistance to mechanical abrasion and attack from iron oxide.

These properties make TAYCOR the ideal refractory for hearths, piers, slot bottoms, front walls, skid rails of forge, heating and heat-treating furnaces . . . for small basic direct arc furnaces operated at higher-than-normal temperatures, requiring long heats . . . for linings of indirect arc furnaces . . . for rammed crucibles of high-frequency induction furnaces. Put TAYCOR to the test in your furnaces. For further information, write direct or call in a Taylor field engineer.

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A SUBSIDIARY OF NATIONAL LEAD COMPANY
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AUGUST, 1954

You Can Obtain...

... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

(1) Fireclay Refractories

An eight-page bulletin available from Harbison-Walker Refractories Co. describes two refractories: "Coleman" for intermediate duty service; and "Coleman XX" for high duty service. In addition to descriptive details, the bulletin includes charts showing spalling resistance, the results of load tests, and thermal expansion.

(2) Lubrication Filters

Published by the Trabon Engineering Corp. is a two-page bulletin, on their series "SH" and "DH" high pressure lubrication filters. These light but sturdy filters are constructed of high tensile cast aluminum with steel sump and tie rod and are built to withstand 1000 psi working pressure and 1800 psi test pressure. The bulletin includes dimensional material, illustrations, diagrams, and comprehensive data charts. (Bulletin 545).

(3) Portable Lighting Lines

A 12-page bulletin is available from the Joy Manufacturing Co. describing their prefabricating lighting and tool lines for industrial needs. The brochure illustrates and provides complete specifications on the latest available designs. These assemblies consist of suitable end connectors and molded Neoprene outlets, factory molded into 50 or 100-ft sections of standard rubber covered cord. As described, they are long-lasting and watertight — and can be adapted to varying job requirements by the addition or deletion of interconnecting sections. (Bulletin B52).

(4) Seamless Mill Machinery

Just issued by the Mannesmann-Meer Engineering and Construction Co. is an eight-page booklet describing and illustrating the various basic components of steel-tube mills, plus basic layouts for a conventional tube mill and a continuous mandrel mill. Emphasis is placed on flexibility of the company's equipment, permitting widely varying and frequent changing operating schedules with one line of equipment.

(5) Heat Treat Pots

Recently released by the Electro-Alloys Division of American Brake Shoe Co. is a six-page bulletin on heat treat pots. Included is a listing of all of the sizes available in their Thermalloy alloy. The back page details suggestions on how pot users may increase service life by proper installation and use. (Bulletin T-234).

(6) Goggle Valves

Two types of goggle valves are illustrated and described in a new 16-page catalog published by Salem-Brosius, Inc. Engineering details are included. These valves, used in large diameter gas mains around blast furnaces and coke ovens, are furnished for gas main sizes up to 108 in. diameter. Special designs of butterfly valves and a new standard line of gate valves are also described.

(7) Motorized Reducers

Of practical interest to men who buy or use gear drives up through 75 hp rating, a new bulletin issued by the Falk Corp. consolidates under one cover the selection tables, dimensions, weights, overhung load ratings, and thrust capacity ratings needed to select horizontal, vertical, or right angle motoreducers in either the all-motor or integral design. A foldout section bound into the middle of the book contains illustrated information on mounting positions, low speed shaft connections, and product features, together with pictures of typical applications. (Bulletin 3100-1954).

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First Class Permit No. 1963, Sec. 34.9, P. L. & R. Pittsburgh, Pa.

IRON & STEEL ENGINEER

1011 EMPIRE BUILDING

PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

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PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	AIR PRODUCTS, INC.		36-page brochure on low-temperature processing.
51	ALDRICH PUMP CO.	DATA SHEET 36	Complete data on new air-driven hydraulic pump.
52	AMERICAN AIR FILTER CO., INC.	BULLETIN 241	Information on automatic, self cleaning filters.
53	AMERICAN BRIDGE DIVISION, U. S. STEEL CORP.		Catalog on types, sizes, capacities, etc., of electric melting furnaces.
54	AMERICAN FLEXIBLE COUPLING CO.	CATALOG 501 & BULLETIN 1052	Information on Amerigear couplings.
55	AMERICAN WHEELABRATOR & EQUIPMENT CORP.	BULLETIN 894	How to descale steel strip at high speeds and low cost.
56	ASKANIA REGULATOR CO.	BULLETIN 161	Details on splitting steel with edge position control.
57	BEDFORD FOUNDRY & MACHINE CO., INC.		Complete Bedford crane catalog.
58	CHANDEYSSON ELECTRIC CO.	BULLETIN D-102	Data on machines for power savings and power dependability.
59	CHEMICAL CONSTRUCTION CORP.	BULLETIN M-102	Complete information on gas scrubbers.
60	CLEVELAND WORM & GEAR CO.	CATALOG 400	Presentation of complete worm gear speed reducer line.
61	DIAMOND POWER SPECIALTY CORP.	BULLETIN 1136	Information on use of wired television.
62	DREVER CO.	BULLETIN B-61	Details on strip annealing furnaces.
63	DURALOY CO.	BULLETIN 8-DU-4	Bulletin on alloy castings.
64	ELECTRIC CONTROLLER & MFG. CO.	BULLETIN 921-OU	Data on EC&M controls.
65	ELLIOTT CO.		Mill motor bulletin.
66	FARREL-BIRMINGHAM CO., INC.		Descriptive bulletin on heavy duty roll grinders.
67	FOXBORO CO.	DATA SHEET AED 330-9	Engineering data sheet on hot blast temperature control.
68	GULF OIL CORP.		Gulf E.P. lubricants for reduction gear drives.
69	HEPPENSTALL CO.		Solutions to materials handling problems.
70	HYATT BEARINGS DIVISION, GENERAL MOTORS CORP.	CATALOG 150	Latest roller bearings catalog.
71	LINK-BELT CO.	BOOKS 2324-A, 2247, 2451 & 2519	Booklets describing gearmotors and gear drives.
72	MINNEAPOLIS-HONEYWELL REGULATOR CO.	DATA SHEET 6.4-11	Information on faster heat-up for high temperature furnaces.
73	MORGAN ENGINEERING CO.	BOOKLET E-8	Describes equipment for heavy service.
74	PITTSBURGH LECTROMELT FURNACE CORP.	BULLETIN 9	Complete Lectromelt furnace bulletin.
75	POST-GLOVER ELECTRIC CO.	BULLETINS 500 AND 510	Details on standard and welded grid resistors.
76	PYLE-NATIONAL CO.	CATALOG 1100 & BULLETIN 1140-2	Complete listing of circuit breaking plugs and receptacles.
77	RELIANCE ELECTRIC & ENGINEERING CO		New booklet on the tools of automation.
78	REPUBLIC FLOW METERS CO.	BULLETIN 802	Full description of low pressure instruments.
79	SHARPLES CORP.	BULLETIN 1264	Data on rolling mill lube oil purifier.
80	WAGNER ELECTRIC CORP.	BULLETIN MU-185	Information on industrial motors.
81	JERVIS B. WEBB CO.		Fully illustrated catalog on conveyors.
82	LEE WILSON ENGINEERING CO., INC.		Single-stack portable base brochure.

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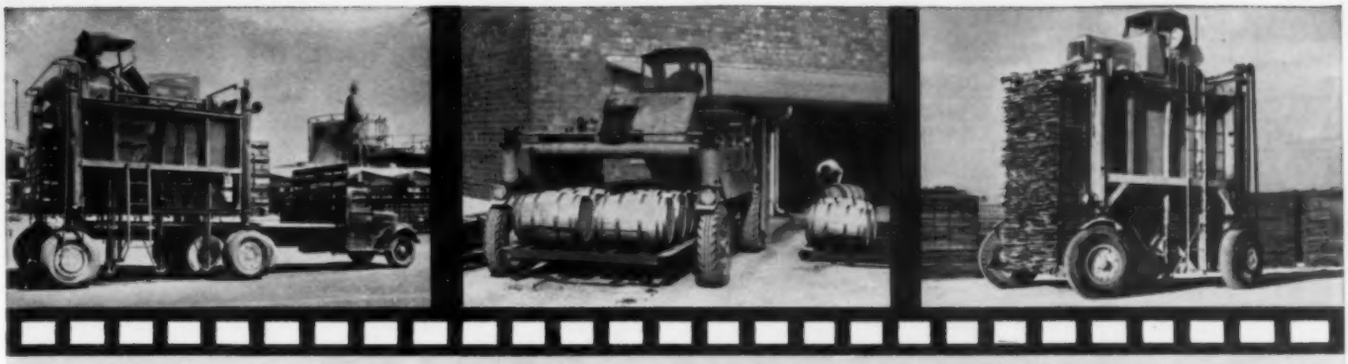

One man loads it . . . in 3 seconds, up to 50,000 lbs. . . .

One man drives it . . . speeds up to 56 mph

One man unloads it . . . in 3 seconds

You are invited to a free showing of

"Over-the-Load Materials Handling"

a 25-minute sound movie starring the **ROSS CARRIER**

You can revolutionize your handling operations! You can move materials faster, farther, at less cost, and this new movie shows you how to do it. As in the above pictures from the film, you'll see the Ross Carrier handling pineapples, whiskey barrels, lumber packages, heat exchangers, cotton bales, steel tube—for aggressive, cost-conscious companies which have discovered the unique advantages of over-the-load handling. If you are sincerely interested in knowing what's new in materials handling, you won't miss this free movie. It's available on a loan basis—simply send the coupon to reserve your showing. We'll mail the film to you—your only cost is return postage.

CLARK EQUIPMENT

ROSS CARRIER DIVISION
CLARK EQUIPMENT COMPANY
Benton Harbor 135, Mich.

Send "Over-the-Load" movie for showing on (give 2 choices):

Dates 1) 2)

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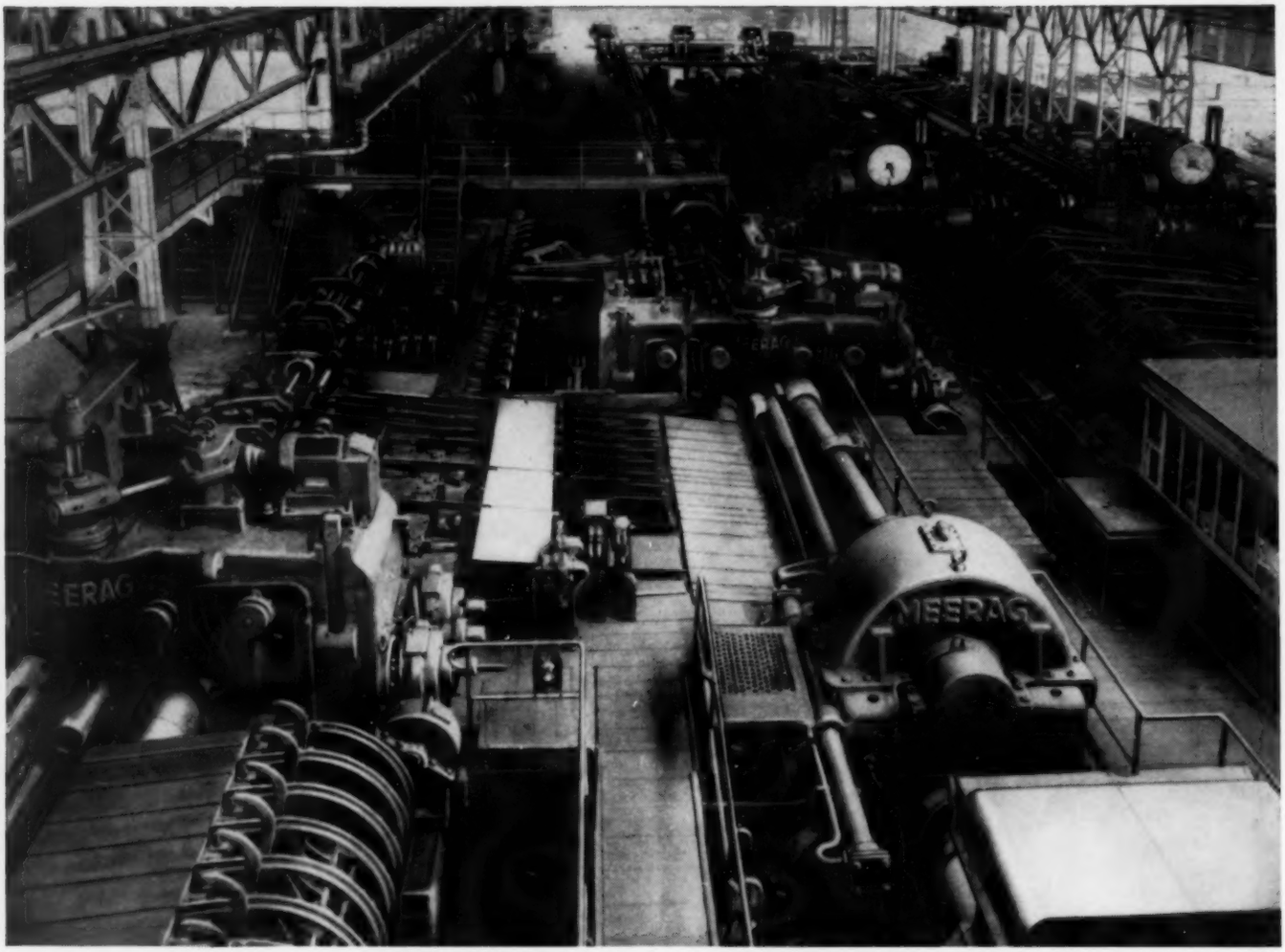


WORLD'S FIRST automatic seamless mill equipped with two plug mills (shown at upper right).

Seamless mill cuts costly down-time

• This well-known seamless tube mill had to find a way to make quick changeovers from one operating schedule to a radically different one. Mannesmann-Meer engineers solved the problem by installing two plug mills — the first time it had ever been done in an automatic seamless mill. The idea enabled the operators to cut costly down-time in half.

Here's a typical example of Mannesmann-Meer's ability to meet the growing need for extreme flexibility and versatility in tube mill operation. We're the only seamless mill manufacturer that can draw on years of experience in *mill operation*. This unique background makes Mannesmann-Meer best qualified to meet your seamless mill requirements.

Write us about pipe and tube mill equipment, mechanical and hydraulic extrusion presses for steel and non-ferrous tubing or special shapes, cold straightening machines, hydraulic equipment or other special machinery.

M.3.6

MANNESMANN-MEER

ENGINEERING & CONSTRUCTION COMPANY
900 Line Street, Easton, Penna.

WORLD SPECIALISTS IN HIGH-SPEED TUBE-MILL MACHINERY

DREVER VERTICAL
STRIP ANNEALING FURNACES

. . . for ferrous or non-ferrous metals

5 important advantages

1. VERSATILITY AND FLEXIBILITY
2. ABSOLUTE UNIFORMITY OF ANNEAL
3. MINIMUM FLOOR SPACE REQUIRED
4. HIGHLY ECONOMICAL AND EFFICIENT
5. ELECTRIC OR RADIANT-TUBE-GAS-FIRED HEATED

● *Illustrated are two 1820-KW, 20,000 lbs/hr Vertical Strip Continuous Annealing Furnaces for 42" wide strip.*

Write for Bulletin No. B-61

DREVER CO.

790 E. VENANGO ST., PHILADELPHIA 34, PA.

10

HERE'S THE USG BRUSH

THAT DOES AN OUTSTANDING JOB ON AC CRANE MOTOR RINGS

When you replace the brushes on your AC Crane Motor Rings you can get the best results with U S G Grade 550 Brush. For brushes that give superb results in other applications, see below. Write for your copy of the complete U S G Brush catalog today.

A typical U S G Grade 550 Brush for AC Crane Motor Rings

U S G Grade 135 Mill Motor Brush with Statite*

U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade 1658 Brush for tin line collector rolls

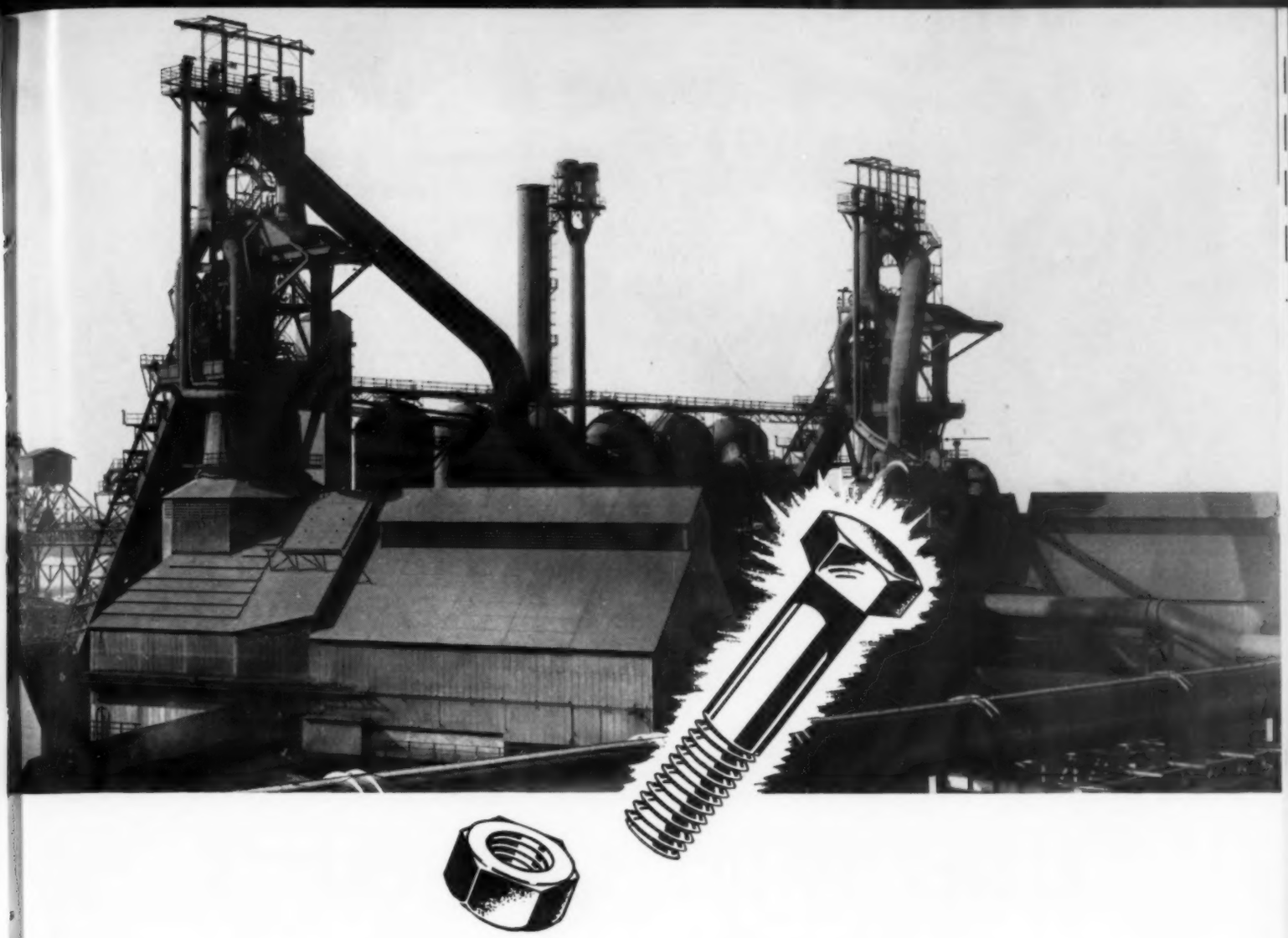
U S G Grade AH897 Brush for welding generators with Statite*

Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

OUR 100th YEAR

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN



Right down to the last Nut and Bolt

ARTHUR G. MCKEE & COMPANY are organized to take complete responsibility for *all details* of your project from the preliminary planning stage through complete construction—literally down to the last nut and bolt.

The advantages of this undivided responsibility are manifold. You are relieved of the necessity of hiring technical help and field crews, of negotiating with numerous sub-contractors and suppliers, of co-ordinating activities and arrival of materials, of time-keeping, supervision, inspection and countless other details.

McKee performs all these functions under a ***single contract*** and with a thoroughness and efficiency born of long, specialized experience.

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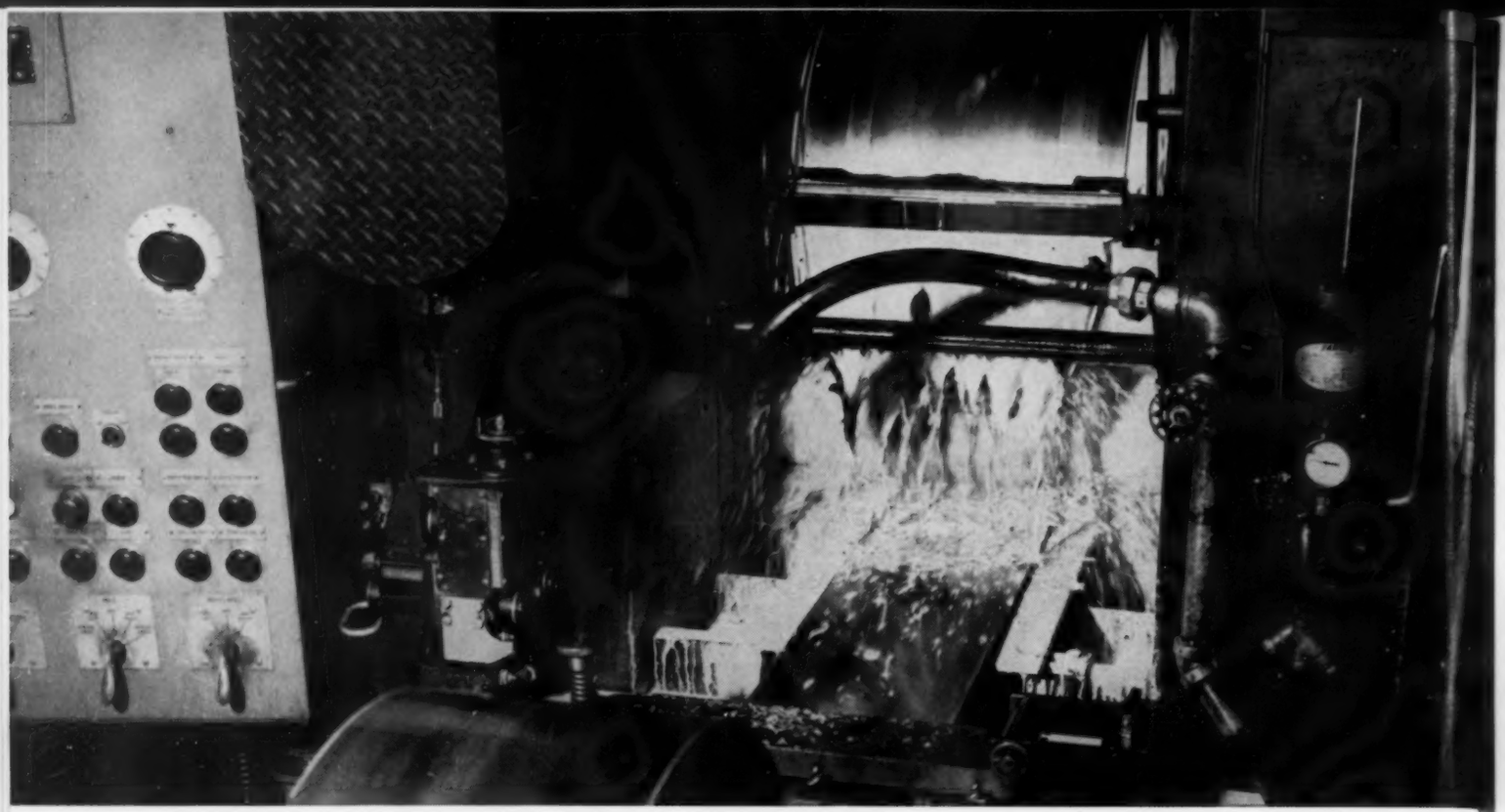


NEW SUNOCO EMULSIFYING ROLLING OIL EASIER TO USE, LASTS LONGER

It mixes readily in hard or cold water—forms whiter and more stable emulsions that can be used for a longer time. The lower viscosity of new Sunoco Emulsifying Rolling Oil makes it easier to pump from storage tanks. These improvements are the result of improved refining techniques made possible by several new multimillion-dollar refining units.

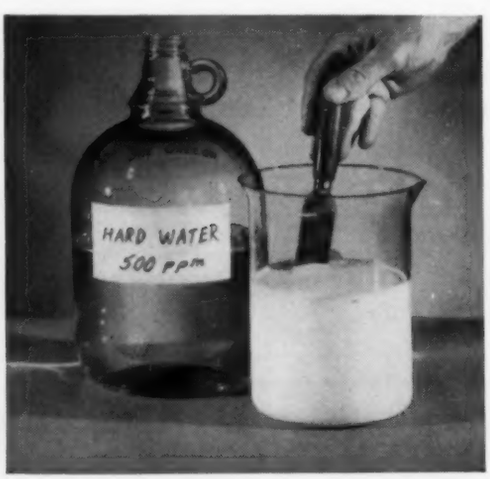
Users report cleaner rolls, reduced spalling, and absence of gumming. The result is lower power consumption and higher mill speeds—as much as 50% in many cases. In the annealing operations, Sunoco Emulsifying Rolling Oil burns off cleanly—usually making cleaning unnecessary. All of these advantages contribute to lower cost operation.

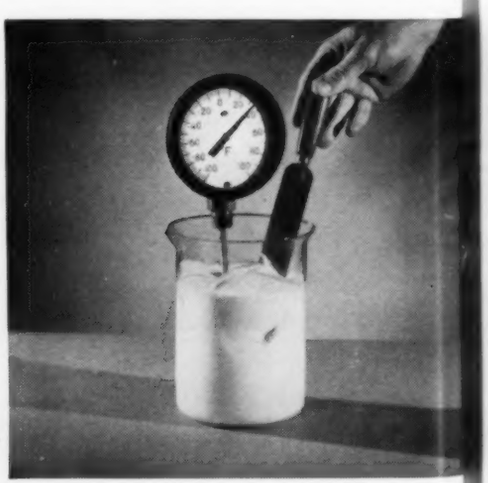
You can also use Sunoco Emulsifying Rolling Oil advantageously for rust proofing hot rolled sheets after pickling, and as a die lubricant in cold drawing steel bars.

The full story about this new oil is well worth your listening. Care to hear it? Just contact your Sun Oil Company representative. Or write Dept. IS-8.

TESTS SHOW HOW READILY THIS NEW OIL FORMS STABLE EMULSIONS

HARD WATER—Tested in dozens of samples of water obtained from industrial plants having hard water problems. Never failed to form a stable emulsion.





COLD WATER—Forms a stable emulsion in the coldest water . . . even ice water.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

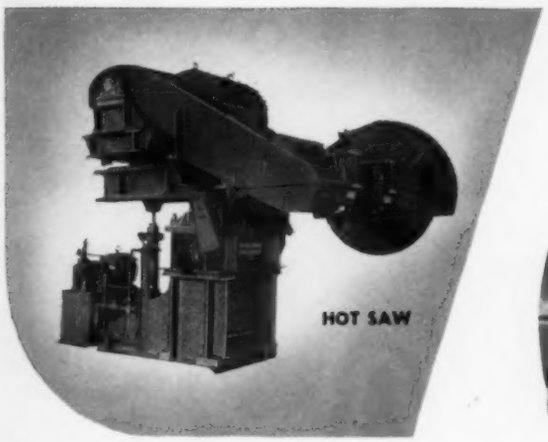
SUNOCO®

PHILADELPHIA 3, PA. • SUN OIL COMPANY LTD., TORONTO & MONTREAL

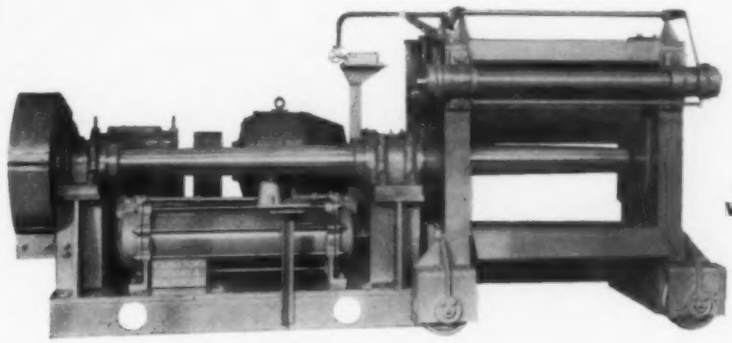
Made by the refiners of famous Blue Sunoco Gasoline and Dynalube Motor Oils

F&Y BUILDS *MODERN MILL EQUIPMENT*

designed to do a better job



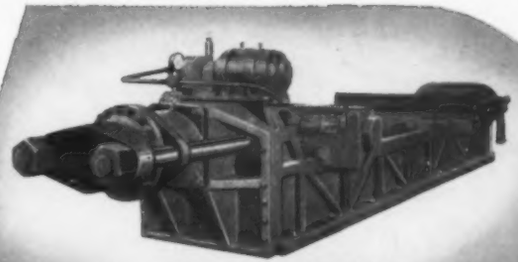
HOT SAW



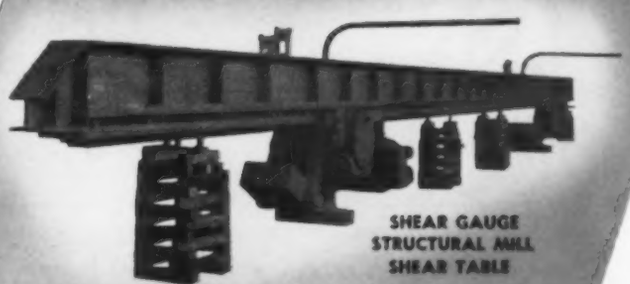
SCRAP WINDER

Products of Proven Performance

- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—Traveling and Lifting Tables
- Continuous PICKLING Lines—ROLLER LEVELERS
- FURNACE Charging Equipment—Furnace Pushers
- Strip Steel COILERS and REELS—SCRAP BALLERS
- RAILROAD Spike Forming Machines—ROLL LATHES
- Sheet GALVANIZING Lines—Wire Patenting Frames
- Stretcher Levelers—Angle and Shape Straighteners
- Rolling Mill Tables—Gear and Individual Motor Types
- PARALLOY ROLLS (Pinch, Coiler, Tension, Steel Mill)
- DUCTILE CASTINGS (80,000 PSI.)



800,000# STRETCHER LEVELER



SHEAR GAUGE STRUCTURAL MILL SHEAR TABLE

PARALLOY ROLLERS

Machinery Built to Customers Design and Detail Drawings

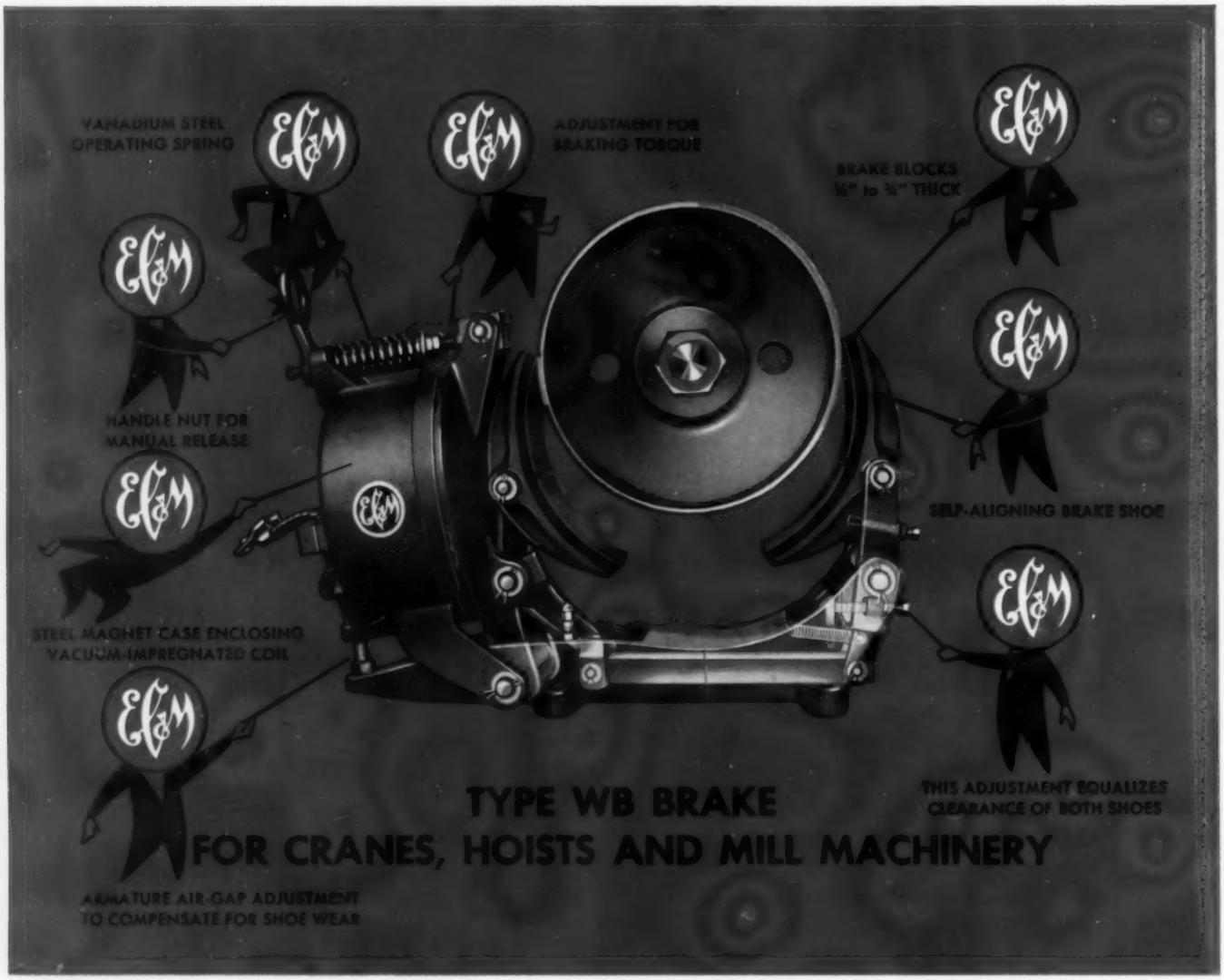
The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

7*

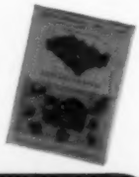
EC&M brakes are built for smoother operation • safer stops • less maintenance


VANADIUM STEEL OPERATING SPRING
ADJUSTMENT FOR BRAKING TORQUE
BRAKE BLOCKS ⅛" to ¾" THICK
HANDLE NUT FOR MANUAL RELEASE
SELF-ALIGNING BRAKE SHOE
STEEL MAGNET CASE ENCLOSING VACUUM-IMPREGNATED COIL
THIS ADJUSTMENT EQUALIZES CLEARANCE OF BOTH SHOES
TYPE WB BRAKE
FOR CRANES, HOISTS AND MILL MACHINERY
ARMATURE AIR-GAP ADJUSTMENT TO COMPENSATE FOR SHOE WEAR

Take a close look at the world's finest heavy-duty brake. Built for both alternating and direct current motors . . . Type WB Brakes are available in 7 sizes for D-c and 4 sizes for A-c operation.

EC&M has combined the finest materials and workmanship with years of experience and engineering research to assure trouble-free service. When you need a brake that is "performance proven" . . . a unit that provides smoother operation, safer stops and less maintenance . . . specify EC&M Type WB Brakes.

Write for literature today.



2046

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79th STREET • CLEVELAND 4, OHIO

Equipment News...

LUBRICANT

▲Recently introduced by the Brooks Oil Co. is a lubricant for preventing leakage in hydraulic systems. While the compound itself is not new, its application for this type of service is a recent development.

Leakage from seals, gaskets, packing, threaded pipe joints and other sources presents three problems—the high cost of replacing hydraulic fluid, a fire hazard, and an expensive plant maintenance problem.

Brooks engineers found that the highly adhesive Brooks SW-301 was effective in reducing or preventing leakage caused by shock or vibration. The material is added to straight mineral oil or other largely petroleum products used as hydraulic fluids.

The lubricant is used with hydraulic fluid in ratios ranging from 1:1 to 1:7. If lower ratios are desired the more viscous SW-601 is used. When used with low price hydraulic fluids such as straight mineral oils, the heavier film on various parts has an added advantage in retarding wear due to increased adhesion and film strength.

The adhesive nature of Brooks Slide and Way Lubricant is obtained by processing and compounding in which nothing is used which could coagulate, form sludge, develop corrosion, emulsify with water, clog screens or in any way disturb the nature of a hydraulic system.

BRAZING UNIT

▲Developed by Selas Corp. of America, a new rotor-brazing technique, greatly increases production rates at reduced operating costs.

The illustration shows the brazing, in less than five minutes, of 64 copper bars to the end ring of a rotor for an industrial electric motor, through the use of Selas Superheat burners. Floor to floor time—which includes loading, heating, cooling, unloading—is only 15 minutes, as compared with 1½ hours for other methods.

The cost of the natural gas consumed in the brazing operations is 3½ cents, as compared with up to $2.00 for torch brazing methods which use oxygen-fuel.

In the specially-designed equipment shown, the work rotates within

an adjustable ring of 14 Superheat burners. Each of these burners is in effect a small jet furnace in which premixed air-gas is burned and hot products of combustion issue forth at high velocities through a slot in the burner. Localized heating is thus accomplished at high speeds, and all copper bars are brazed simultaneously.

Brazing alloy can be pre-placed, instead of hand fed. This feature, plus the fact that the heating cycle is controlled automatically, assures reproducibility of results and releases the operator for other related operations during the heating period.

CENTRIFUGAL PUMP

▲Ampco Metal, Inc., has announced a new series of production-built centrifugal pumps adaptable to almost any special customer requirements. These new 1750 rpm single-suction pumps are available in sizes ranging from fractional flow to 600 gpm.

Units are available from stock constructed entirely from Ampco alloys or nickel chrome alloys to combat the effects of corrosion and erosion. They are particularly designed to transfer liquids that are normally difficult to handle because of their erosive and corrosive nature.

The unique feature of this new line is the ease and rapidity with which pump components may be interchanged to fit the requirements of various specialized jobs, thus per-

BELT CONVEYOR MODEL BUILT BY GOODYEAR

This working model of the Riverlake Belt Conveyor Lines system that will transport coal and iron ore between Lake Erie and the Ohio River via Youngstown, has 6776 moving parts. Built in three sections, end panels depict modern river and lake terminal loading and unloading operations, and central unit shows elevated two-way belts hauling cargoes cross-country along 100-mile route. Goodyear Tire and Rubber Co. constructed the model.

mitting the customer to satisfy all the requirements of his operation and get a pump that is tailor-made for his job without going to the expense of a special unit.

The new series is engineered and designed to permit field changes at low cost. All three types of bearing lubrication are available with the Ampco Pump—the customer has his choice of permanent sealed double width bearings, replenishable grease or oil lubricated types—whichever best suits his needs. He can select either medium or light-duty bearings to match his choice of shafts, depending on the pump's contemplated use.

Either type of basic shaft seal can be specified—packed stuffing-box or mechanical. Packed stuffing-boxes have either internal, external or flushing seals and may be changed from one to the other by rotating a single part. The customer can make any known stuffing-box arrangement without changing parts or dismantling. Water-cooled boxes are also available. Both inside and outside mechanical seals are applied interchangeably to these pumps without excessive shaft overhang. Space is provided for seals to be lubricated and/or cooled.

The problem of overgreasing is eliminated — a correctly designed pump casing is by nature intricate and difficult to cast. For this reason and for other design advantages, these pump casings are fabricated to assure sound, compact and economical construction — blind tapping is eliminated and there are no heavy shrink areas to cause porosity. Joints are designed so gaskets are confined and under uniform load, regardless of changing temperature and pressure conditions.

These new pumps will be stocked in all Ampco alloys and high nickel-chromium alloys. For highly specialized cases, Ampco centrifugal pumps can be obtained on special order made from any other workable metals. Pumps can be built from Illium (Stainless Foundry & Engineering Co., Milwaukee) "G," Hastelloys, Nickel, Nickel-Copper, Stainless Steels, etc.

AUTOMATIC TONGS

Railroad wheel surfaces are machined at the touch of a finger with this unique equipment at the McKees Rocks Wheel and Axle Division of U. S. Steel Corp.'s Homestead Works. One wheel is bored and another faced while a completed wheel is being removed and another readied for boring and facing. Standard 33-inch MCB wheels are completed at the rate of about 27 an hour, under the control of one man at the push-button panel. The three-jawed tongs, made by Heppenstall Co. will accommodate wheels ranging from 20 to 44 in. in diameter.

GLAZED BLOCK

▲ A new ceramic glazed concrete block, designated the "Glasface," was announced by Ferro Corp., Cleveland, Ohio. The new block which makes possible installation of a concrete block wall without the necessity of additional finish, is available in a complete range of colors as well as various types of finishes, including mottling and stippling.

The ceramic glazed finish on the block, resistant to scratching and fire, can be applied by the Ferro process to the many expanded clay, shale or blast furnace slag type blocks. Extensive tests, however, have shown the finish to be best applicable to the so-called lightweight aggregate type of block.

Tests indicate that there is a slight loss of crushing strength produced during the firing of the block, but the final figure is still well above the ASTM specification for a Class A block. Further tests at the University of Toledo have shown that the glazed block can stand a hydrostatic pressure of 15 in. of water on the reverse side without showing any signs of peeling.

The process, in substance, consists of taking the Ferro-developed fine

ENTERPRISE

60 In. Heavy Duty FORGE LATHE

USED BY LEADING FORGE SHOPS IN THE UNITED STATES
YOU, TOO, SHOULD INVESTIGATE

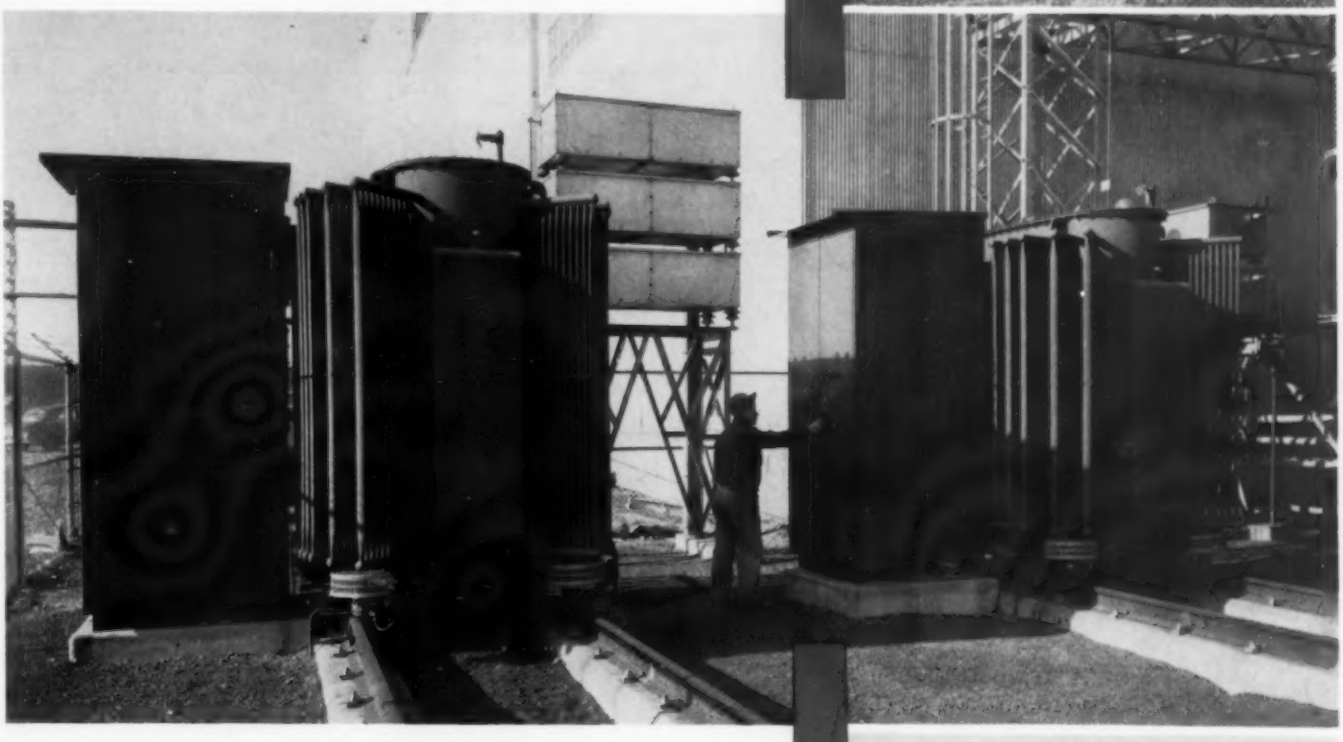
Especially designed for both rough turning and finishing of heavy forging, crankshafts and rolls. Engineered to withstand unusually large overloads, this lathe will provide maximum production and many years of trouble free performance.

Get complete details by writing for Bulletin 301—Today

ESTABLISHED 1870

THE ENTERPRISE COMPANY
MACHINERY BUILDERS & ENGINEERS
SUBSIDIARY OF WM. K. STAMETS COMPANY · PITTSBURGH
COLUMBIANA 1, OHIO · U. S. A.

23 PENNSYLVANIA UNIT SUBSTATION TRANSFORMERS feed all 2400 volt lines at United States Steel's Fairless Works



19 — 2500 Kva and 4 — 3750 Kva Pennsylvania Transformers are supplying power at 2400 volts to operate open hearth furnaces, blast furnaces, hot and cold rolling mills, and coke ovens at the famous Fairless Works. Functioning as important components of I-T-E Unit Substations, these Pennsylvania Transformers assure an uninterrupted flow of power from the 13,800-volt power system to the 2400-volt distribution system.

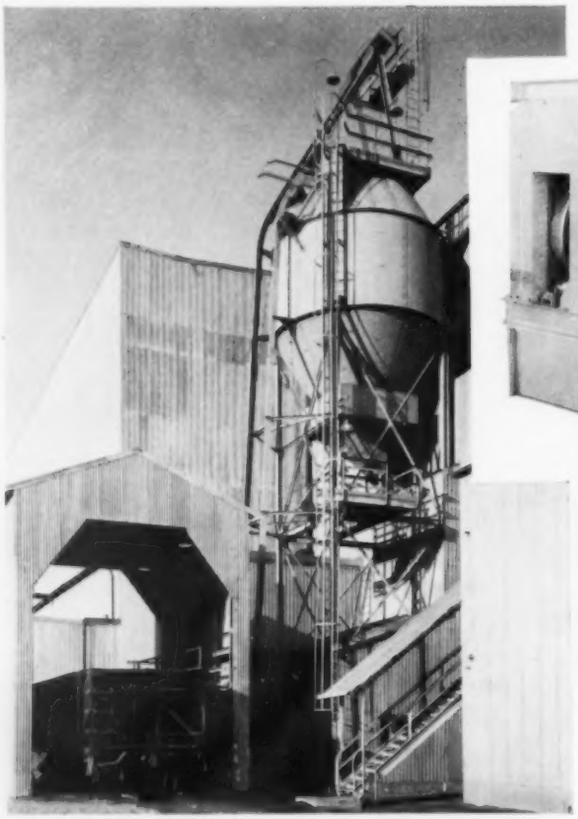
Pennsylvania Transformer Company manufactures a complete line of power and distribution transformers, 3 Kva through 300,000 Kva, in voltages up to 330,000 volts.

PENNSYLVANIA TRANSFORMER COMPANY

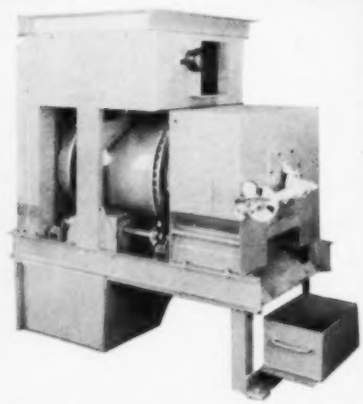
A McGraw Electric Company Division • **Box 330** • **CANONSBURG, PA.** • **Phone Canonsburg 2380**

"Ready for Service"
COKE BREEZE—
SAND PLANTS

designed, built, equipped and turned over to you ready for the individual type service dictated by your specific requirements.



Coke Breeze Plant serving soaking pits at a plant of a major steel company. Supplied "ready for service."



R & S Automatic Roto-Drum Dryer suitable for production or pilot plant operation—a sand drier for Diesel Service or for the processing industries.

Sand Preparation and Storage Equipment serving Diesel locomotives. Supplied "ready for service."

Roberts & Schaefer Co. does the complete job, employing principles and practices they have tested and proved over a period of 50 years. Combining within a single organization the functions of Engineering, Fabricating and Contracting, this group of experienced engineers adapts these proven principles and methods to meet your specific requirements.

What Processing or Bulk-Material Handling problem do you now have . . . ore, dolomite, by-products, coal or something else? If it is processed, hoisted, transported or stored, R & S complete service can help you — whether your needs are for a completely new plant or modernization of present equipment.

Main and District Offices conveniently located for consultation.

ROBERTS & SCHAEFER CO. *Engineers • Fabricators • Contractors*

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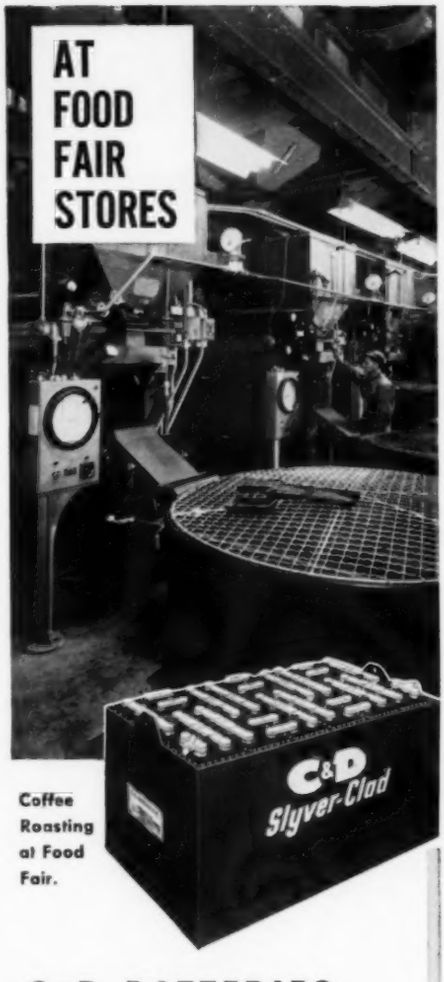


Coffee Roasting at Food Fair.

C&D BATTERIES
FOR EXTRA WORK!

Food Fair Stores, Inc., one of America's fastest growing food chains, is currently ringing up sales at the rate of $400,000,000 a year. To help handle the millions of pounds of dry groceries, meat, produce, and other products that move through the company's warehouses every week, Food Fair uses C&D Slyver-Clad* batteries as a major source of power in their industrial trucks. For Food Fair, like hundreds of other leading American companies has found it pays to power with C&D Slyver-Clad batteries.

C&D Slyver-Clad batteries are approved as standard equipment by all electric truck manufacturers. For further information, write for catalogs.

**TM Reg.*

C&D
BATTERIES, INC.
of Conshohocken, Pa.

Manufacturers of Industrial Batteries since 1906
SALES AND SERVICE OFFICES
IN PRINCIPAL CITIES FROM COAST TO COAST

glazed powder and mixing it with water with a "lightning-typhoon" type electric mixer for a few minutes, and then spraying this material to the face surface of the concrete block. The block is then dried and fired at 1160 to 1200 degrees F in a special type of kiln produced by the Ferro Corp. Normally, two coats of glaze are required for the block.

Book Reviews . . .

"ASTM Standards on Materials for Radio Tubes and Electronic Devices and Electrical-Heating, Resistance, and Related Alloys," 6 x 9 in., heavy paper cover, 244 pages, $2.75, includes in the 1954 edition 44 widely used ASTM standards, including 30 test methods; 10 specifications; and 4 recommended practices. Most of the standards have been developed through the work of ASTM Committee B-4 on Electrical-Heating, Resistance, and Related Alloys. Also included are related standards from other committees. Materials and subjects cover: electrical-heating alloys; electrical-resistance alloys; electric-furnace alloys; radio tubes, electronic devices, and lamps; heat-resisting alloys; electrical contact materials; and thermostat metals.

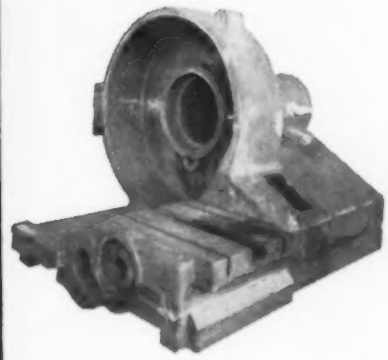
"Geschichte des Eisens" (History of Iron), by O. Johannsen, third edition; 579 pp, 8⅛ in. x 11¼ in., 433 illustrations, was published in 1953 by Stahleisen, Dusseldorf. 75 German marks. To write a comprehensive and accurate history of iron is a herculean task, which was well accomplished by Dr. Johannsen. He begins by describing and illustrating prehistorical finds, mostly meteoric and brings what little is known about the making of iron by the ancients around the Mediterranean. Very interesting is the development of the iron industry from the early to the late middle ages. It flourished, where there was ore, wood, and water. The author describes the making of charcoal, mining and preparation of ores, furnaces for making malleable (wrought) iron and cast iron, and conversion of the metal into useful aritcles. The making of charcoal iron in many countries, including America, is described. Then fol-

(*Please turn to page 244*)

Hyde Park
RED CIRCLE Rolls ALLOY-CHILLED

Gray Iron Castings

Castings of any size up to 80,000 pounds. Hyde Park facilities are equal to your every requirement



Machine Castings
Lathe Beds
Housings
Pinion Housings
Mill Housings
Shoe Plates
Layout Plates
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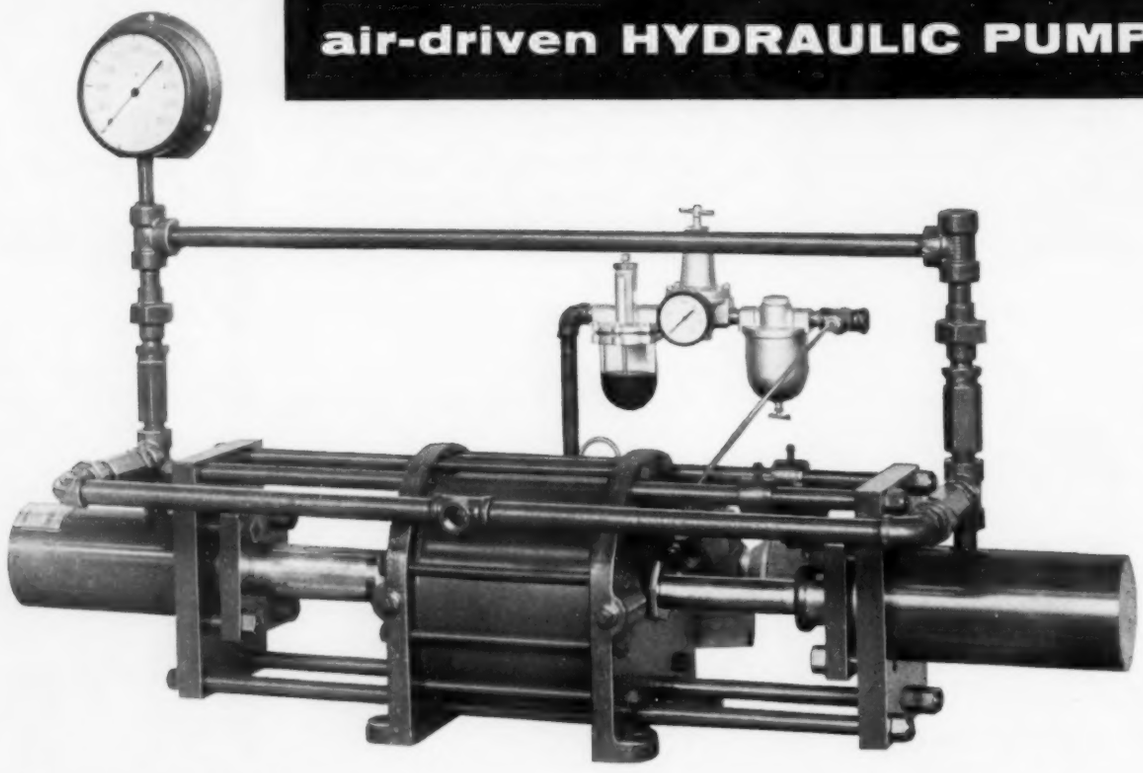
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

new!

ALDRICH

air-driven HYDRAULIC PUMP



. . . *for small volume capacity at low or high pressures*

Here is a new pump that will develop up to 30,000 psi from ordinary 90 psi plant air—without auxiliary equipment! This air-driven hydraulic pump is self-contained, complete with regulator, air filter, lubricator and pressure gauge.

New design provides economy of operation for many industrial applications—

- *supplying power for molding and belt presses*
- *testing tubing, valves or pressure vessels*
- *ideal for laboratory as well as production use*
- *and for many other applications requiring small volume capacity at low or high pressures.*

Special muffler design provides quiet operation.

Aldrich Air-Driven Hydraulic Pumps are available in low and high pressure models, single or double-acting. Plunger diameters for the low pressure range are 1¼″ to 3″. High pressure range, ½″ to 1⅛″. Double-acting units provide minimum pressure fluctuations in addition to greater volumes.

Write for *new* Data Sheet 36 for complete details.

the ALDRICH *pump company*

. . . Originators of the Direct Flow Pump

21 PINE STREET • ALLENTOWN, PENNSYLVANIA

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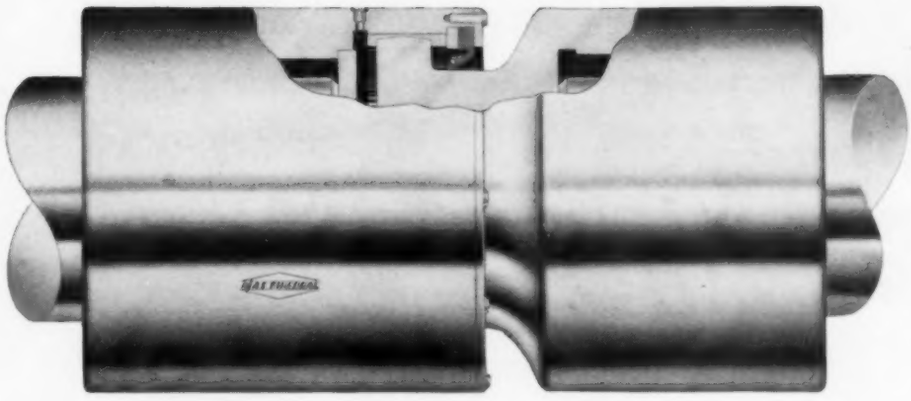
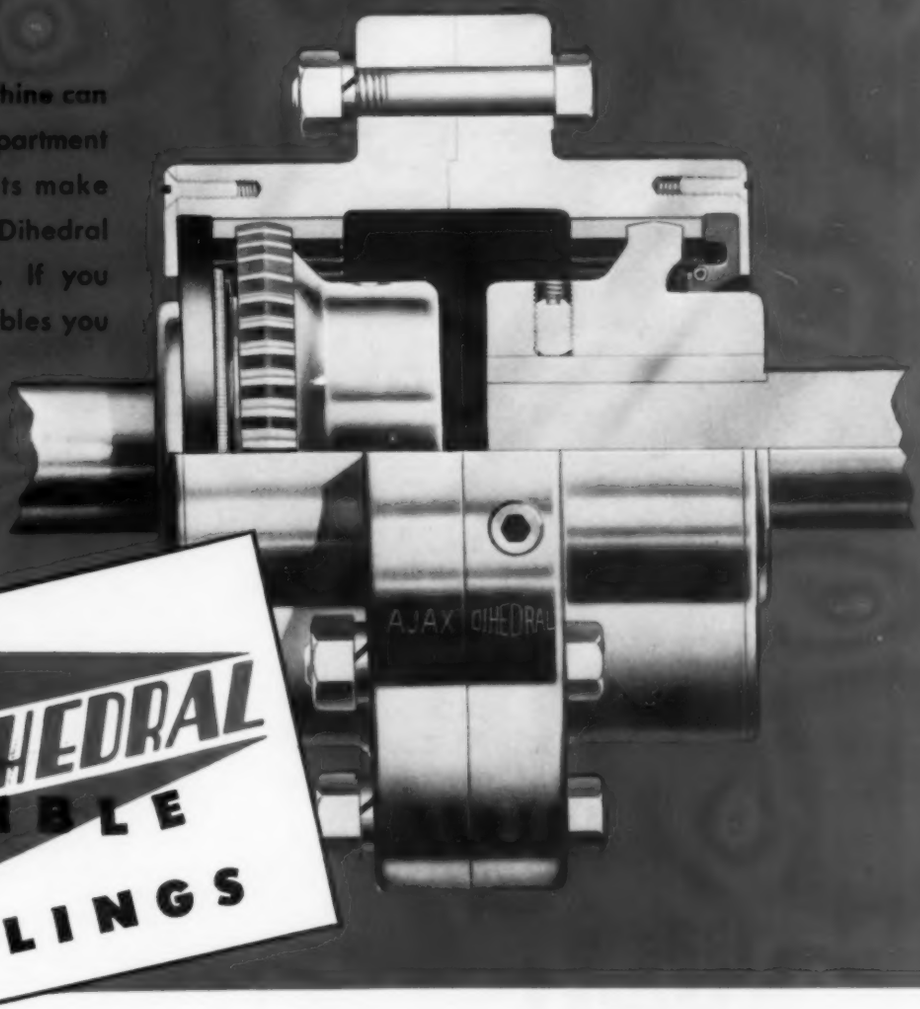
FIGURE YOUR COSTS, – *you will forget the price*



AJAX DIHEDRAL SPINDLE SHAFT COUPLING DESIGN is responsible for long life, trouble-free operation without the usual maintenance on spindle drives between pinion stands and rolls. Tell us your misalignment troubles.

Shutting down one machine can shut down an entire department or mill. Downtime costs make the extra price of Ajax Dihedral Couplings insignificant. If you have misalignment troubles you can't afford to be without Ajax Dihedral Couplings.

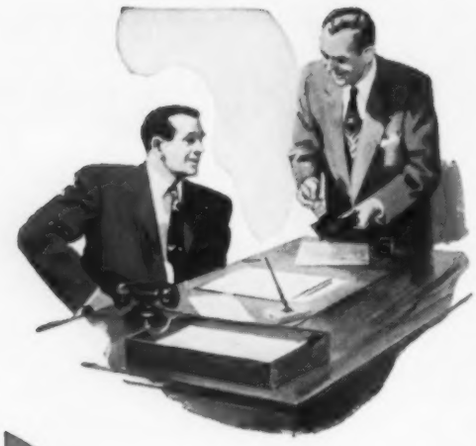


AJAX DIHEDRAL
FLEXIBLE
COUPLINGS

AJAX FLEXIBLE COUPLING CO. INC.

Representatives in Principal Cities

WESTFIELD, N. Y.



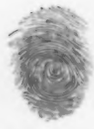
SEE RUST-OLEUM APPLIED DIRECTLY OVER SOUND RUSTED SURFACES! MAKE THIS TEST UNDER YOUR OWN CONDITIONS AND SEE PROOF OF PERFORMANCE!

See Rust-Oleum 769 Damp-Proof Red Primer actually applied over a badly rusted surface after simple scraping and wire-brushing to remove rust scale and loose rust in the Rust-Oleum *"rusted panel demonstration."* Rust-Oleum's specially-processed fish oil vehicle *penetrates* rust to bare metal usually eliminating sandblasting and other costly surface preparations.

Rust-Oleum finish coatings in Aluminum, Green, White, Gray, Yellow, Black, Orange, Blue and others provide both *Rust Prevention* and *Decorative Beauty!* Specify Rust-Oleum for new construction, maintenance, and re-modeling. See Sweets for complete catalog and nearest Rust-Oleum Industrial Distributor, or attach coupon to your business letterhead.

RUST-OLEUM®

STOPS RUST!



There Is Only One Rust-Oleum. It Is Distinctive as Your Own Fingerprint. Resists Rain, Sun, Fumes, Snow, Heat, Salt Air, Salt Water, etc.

See local classified telephone directory under Rust Preventives or Paints for nearest Rust-Oleum Industrial Distributor.

ATTACH TO YOUR BUSINESS LETTERHEAD AND MAIL TO:
Rust-Oleum Corporation, 2443 Oakton St., Evanston, Ill.

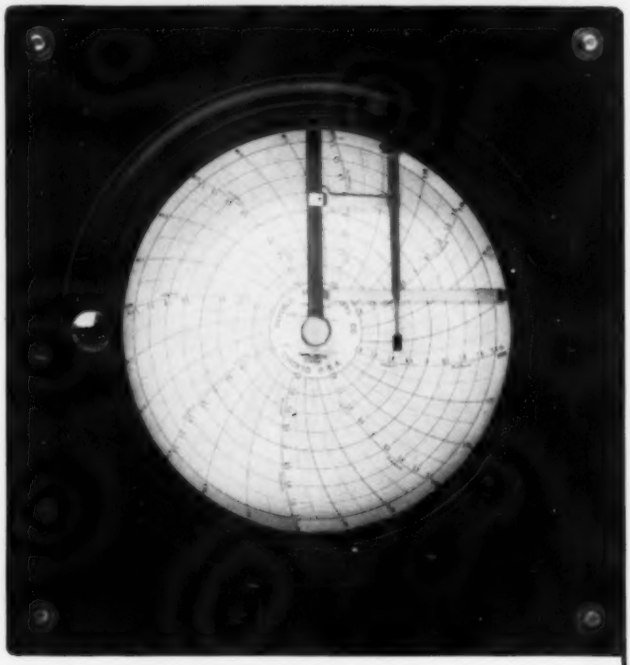
- ☐ Please Show Me the Rust-Oleum "Rusted Panel Demonstration."
- ☐ Test Application of Rust-Oleum Over Rusted Metal Surfaces in My Plant.
- ☐ Complete Literature with Color Chart.
- ☐ Nearest Rust-Oleum Industrial Distributor.

accurate— sensitive— trouble-free— easy to service—

Four reasons for choosing these Republic Low Pressure Instruments to measure flow or pressure of gas and air

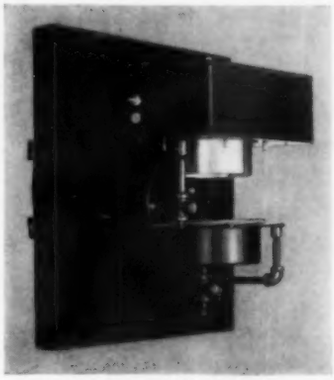
in

OPEN HEARTH FURNACES
SOAKING PITS
REHEATING FURNACES
COKE OVENS
SMELTING FURNACES

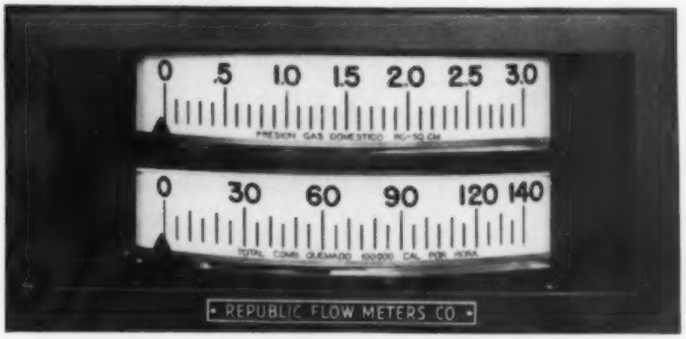


Republic Oil Sealed Bell Recorder at left responds to the slightest changes in furnace pressure and stack draft, and works independently of other controls. Operating principle is so simple that a minimum of maintenance is required. Sealed bell withstands high temperatures and will not crack, rupture or wear out. For pressure or vacuum measurement, the Recorder may be connected directly to a furnace or pipe line. For differentials, it may be connected across an orifice.

Recorder has ranges 0-0.2″ H_2O and 0-8″ H_2O at static pressures to 10 psi. On low range, large 4″ diameter bell gives sensitivity of ±.001″ H_2O.



For quick periodic inspection and cleaning, mineral oil reservoir at rear of Recorder may be lowered by disconnecting one pressure connection and four bolts. Calibration is not changed.

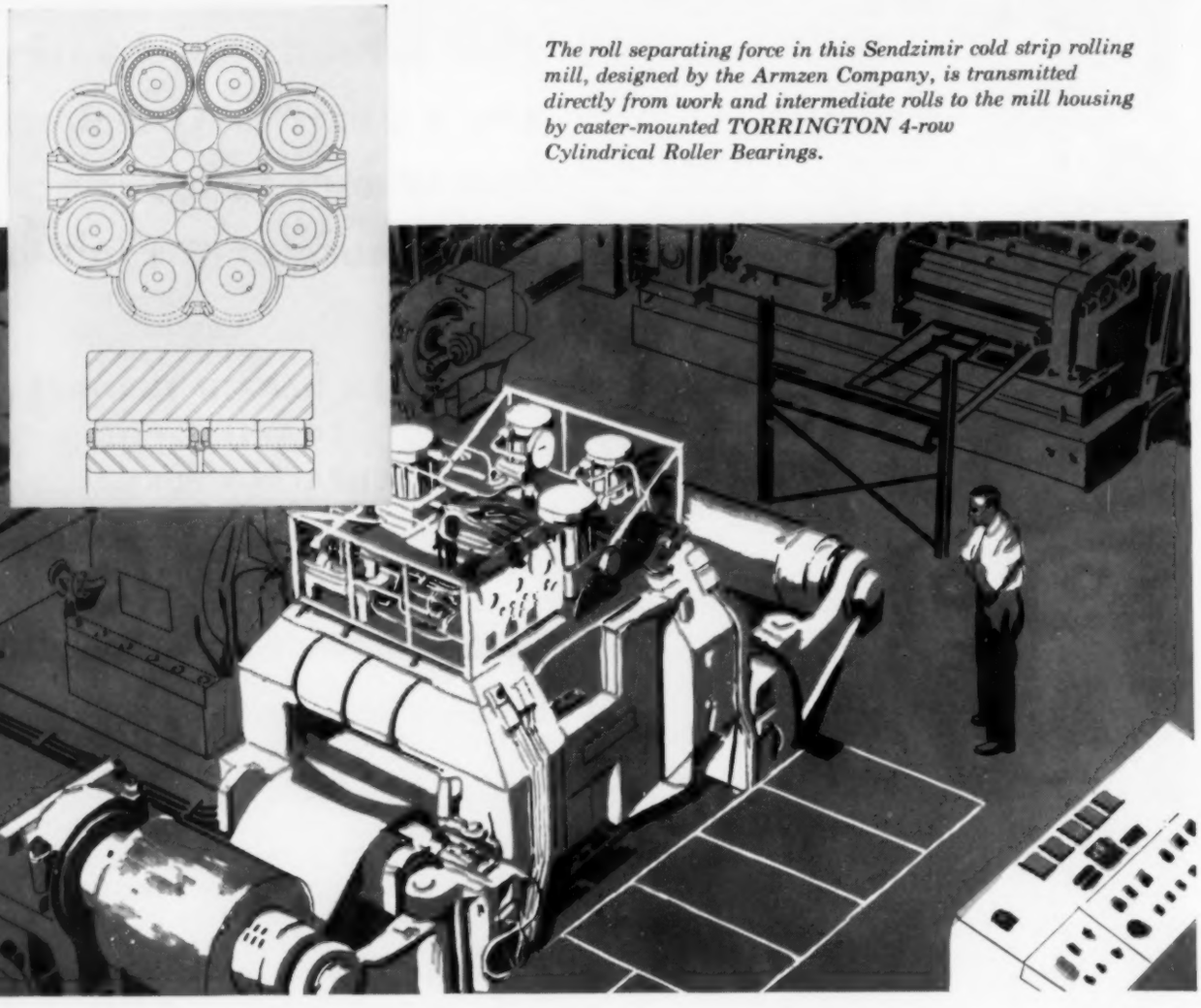


Horizontal Indicator is operated by a tough, resistant diaphragm made of polythylene plastic. Each Indicator is separate and may be individually removed or adjusted. Indicator arm swings on jeweled bearings for friction-free accuracy. Internally illuminated scales may show pressure, draft, pressure-draft combination or differential pressure. Ranges from 0-0.2″ H_2O to 0-40″ H_2O.

Two Indicators are often mounted together to read air flow—gas flow ratio in furnace firing. They may be calibrated so their pointers line up when air and gas are in the correct ratio.

Both instruments fully described in Bulletin 802. Write for your copy today.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois



The roll separating force in this Sendzimir cold strip rolling mill, designed by the Armzen Company, is transmitted directly from work and intermediate rolls to the mill housing by caster-mounted TORRINGTON 4-row Cylindrical Roller Bearings.

Tissue thin strip to finest tolerances!

Fine gage cold-rolled strip accurate to tolerances of one to two ten-thousandths; that's the kind of precision work TORRINGTON Cylindrical Roller Bearings can produce.

Small diameter work rolls, plus a unique roll-backing principle giving minimum distortion, make the accuracy of this mill possible.

The TORRINGTON Bearings provide rigid backing for the intermediate rolls by utilizing outer races of especially heavy section, and four rows of precision-ground rollers in machined bronze cages for positive roller guidance.

This is an example of Torrington's ability to engineer anti-friction bearings to meet special requirements. TORRINGTON Bearings are available in a complete range of types to handle any combination of radial and thrust loads. To assure minimum friction, high capacity and long life, specify TORRINGTON Bearings.

THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

P&H MILL TYPE CRANES

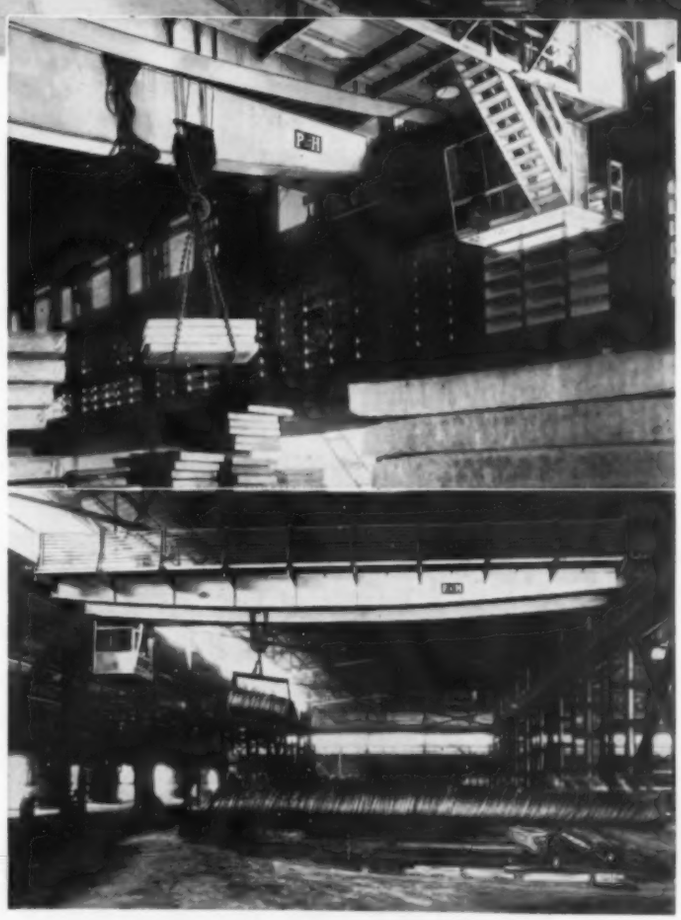
Preferred by Steel Men

because:

P&H Mill Type Cranes are built in excess of the minimum requirements of the A.I.S.E. specification.

This is only one reason why P&H Mill Type Cranes have won such an outstanding reputation. They deliver fine service . . . dependable through the years . . . with fewer interruptions . . . lower maintenance costs.

The overwhelming preference for P&H is evidenced by the fact that there are more than 2,000 P&H Overhead Cranes in steel mill service alone.



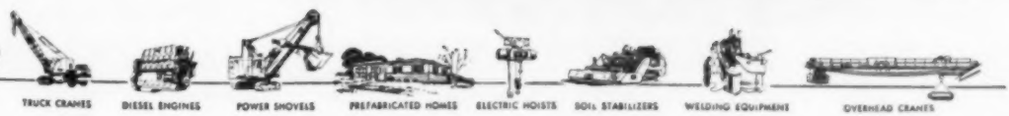
P&H OVERHEAD CRANE DIVISION

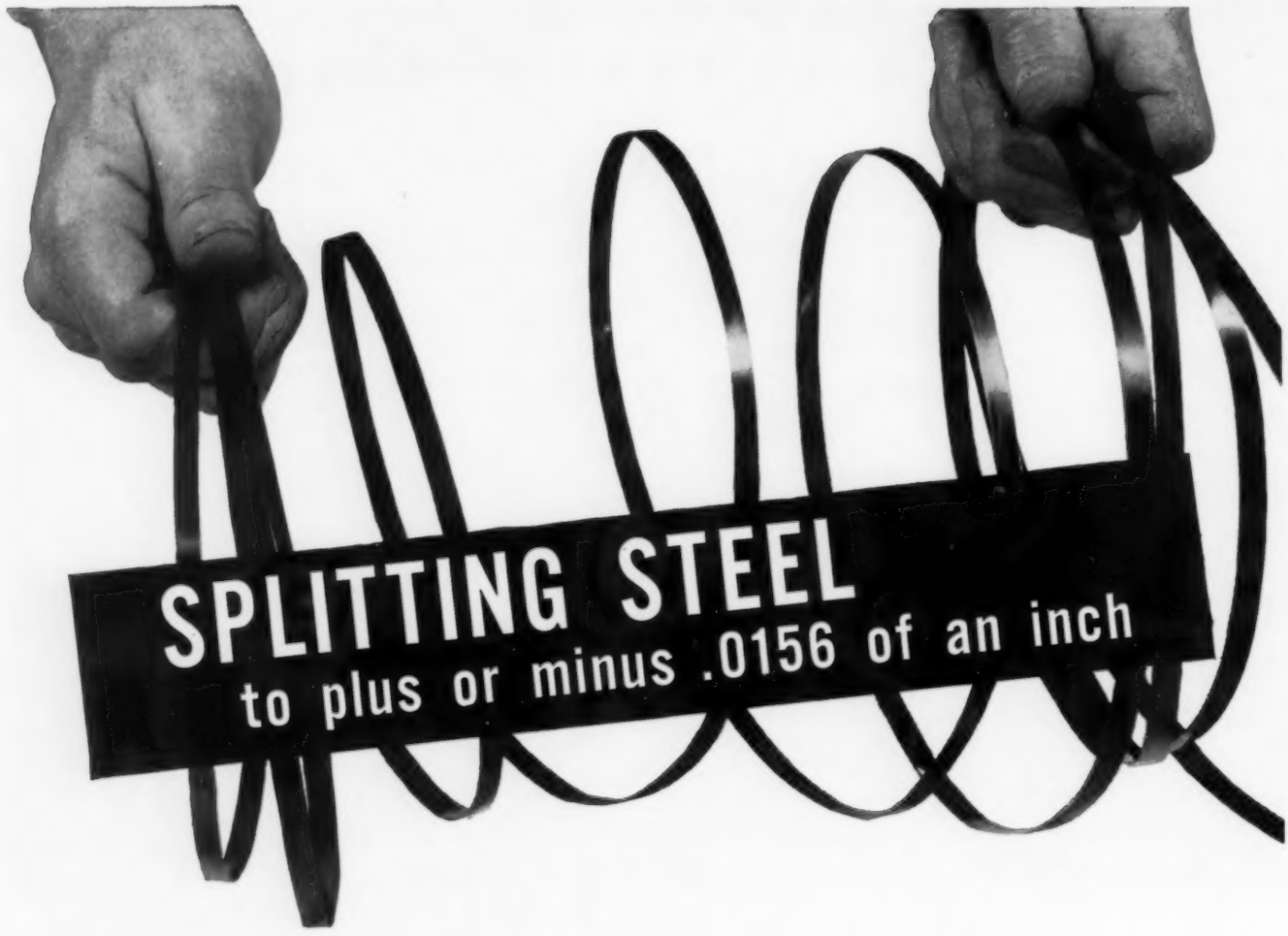
HARNISCHFEGER

CORPORATION

MILWAUKEE 46, WISCONSIN

the P&H Line





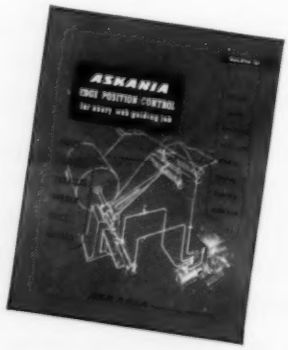
with ASKANIA Edge Position Control

A Pittsburgh district steel mill slits this ¼" rough edge from 15-ton reels of blackplate at 3,000 feet per minute with accuracy of ± 1/64". They do this precision edge-positioning job with Askania Hydraulic Edge Position Control.

Askania Edge Position Control is a new use for the Askania Jet Pipe Regulator, long the educated muscle of the steel mill. Steel men asked for it, because they needed the dependability and simplicity of Askania in this control job.

Nothing touches the steel but a stream of low pressure air. Available force is practically unlimited. The equipment is low in cost. There is nothing delicate about it. It's built to take all the abuse that continuous operation in hard service can give it.

Find out now about Askania Edge Position Control. See your Askania Representative, or write for Bulletin 161.



ASKANIA REGULATOR COMPANY
246 E. Ontario Street, Chicago 11, Illinois
A Subsidiary of General Precision Equipment Corporation

THE ENGINEERING MART

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POSITIONS VACANT
POSITIONS WANTED

AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

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METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
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STEEL MILLS—INDUSTRIALS UTILITIES
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REEVES—Variable Speed Drives
THOMAS—Flexible Couplings
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CULLEN-FRIESTEDT—Sheet Lifters—Welding Positioners—Track Cranes

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Send data on Engineering & Construction facilities for
ACID-ALKALI-PROOF CONSTRUCTION
of pickling and other tanks; flooring.
(TEAR OUT & MAIL WITH LETTERHEAD)

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"Centralized Lubricating Systems"

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PRODUCTS

POSITIONS VACANT

Blast Furnace Superintendent
Qualified Blast Furnace Superintendent or Assistant on single stack plant. Give experience, education and salary expected. Write in detail. Box 802, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pa.

THE ENGINEERING MART
(CONTINUED)

POSITIONS VACANT

WANTED:
Director of Steel Research

We want a thoroughly experienced research man to head up a metal and steel product program in a central midwest growing steel mill. Especially interested in receiving applications from those whose experience has encompassed research problems dealing with silicon and alloy steels. The lack of this experience need not disqualify likely candidates. Fine opportunity and bright future is ahead for the man who wants to organize a group to work at his direction. Give full details of experience and salary requirements. Replies will be held in strict confidence. Our people know of this situation.

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AVAILABLE
for Prompt Delivery
MAGAZINE TYPE SLAB UNPILER

For Handling Slabs up to 74" Wide x 20' Long Piled 3'-4" High.

Slabs are Removed One at a Time for Feeding to the Furnace Approacch Table.

For Additional Information
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IRON AND STEEL ENGINEER
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THE COST OF AN AD THIS SIZE IS $8.00 PER INSERTION

AVAILABLE
for Prompt Delivery
FORGING PRESS MANIPULATOR

With Integral Hydraulic System, Drives and Electrical Equipment, for Handling and Manipulating Forging Ingots weighing up to 75 Tons.

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USE THE ENGINEERING MART

BOOK REVIEWS

(*Continued from page 235*)

lows the period of supremacy of England. The introduction of English processes into other countries is described. Then follows a section on modern history. Reviewed by W. W. Trinks.

"ASTM Standards On Gaseous Fuels" 1954 edition, contains in their latest approved form all of the ASTM test methods used in this field. The test methods cover: measurement of gaseous fuel samples; sampling (Natural gas; manufactured gas; liquefied petroleum gases); analysis of (natural gases by the volumetric-chemical method; natural gases and related types of gaseous mixtures by the mass spectrometer; carbureted water gas by the mass spectrometer); gaseous fuels (water vapor content, by measurement of dew-point temperature; calorific value, by the water-flow calorimeter; specific gravity); sulphur in petroleum products ad liquefied petroleum gases by the CO_2-O_2 lamp method; vapor pressure of liquefied petroleum gases. Copies of this 184-page publication, heavy paper cover, 6 x 9-in., can be obtained from Headquarters of the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $2.50 each.

CITY OF VANCOUVER
BRITISH COLUMBIA, CANADA

NOTICE TO CONTRACTORS

Demolition and Removal of the Old Granville Bridge

SEALED TENDERS are invited from Contractors for the demolition and disposal of the old Granville Bridge over False Creek and Granville Island, Vancouver, B. C.

TENDERS WILL BE RECEIVED BY THE UNDERSIGNED NOT LATER THAN 9 A.M. SEPTEMBER 14TH, 1954, AND SHALL BE MARKED "TENDER FOR DEMOLITION OF OLD GRANVILLE BRIDGE." TENDERS RECEIVED AFTER TIME NOTED WILL BE RETURNED UNOPENED.

Plans, Specifications, Form of Tender and other particulars may be obtained at the office of the City Engineer, City Hall, Vancouver, B. C. upon payment of the sum of Twenty-five Dollars ($25.00) which sum will be refunded on the return of the plans, specifications and other documents in good condition.

Each tender must be accompanied by the sum of $10,000.00 or in lieu thereof by a cheque certified by a Vancouver Branch of a Chartered Bank in Canada for the sum of $10,000.00, payable to the City of Vancouver, or by a bid bond of a Guarantee Company, authorized to carry on business in the Province of British Columbia, for payment to the City of Vancouver of the said amount, conditioned upon the due execution of a formal contract with the City of Vancouver satisfactory to the City Solicitor. The said sum of $10,000.00 or the amount of the said cheque or bond of the successful tenderer will be forfeited to the City of Vancouver aforesaid, should he decline or fail to enter into a contract for the work as aforesaid, within six days after being notified by the City Solicitor so to do.

The certified cheque or bond accompanying each unsuccessful tender will be returned to such tenderer upon the awarding of the contract to the successful tenderer.

The successful tenderer will be requested to furnish a performance bond for the sum of One Hundred Thousand Dollars ($100,000.00) in a form approved by the City Solicitor, conditioned upon the due and proper performance of the Contract. When the said performance bond has been furnished the said bid bond or cheque for Ten Thousand Dollars $10,000.00) of the successful tenderer will be returned.

Tenders must follow the Form of Tender supplied by the City Engineer. The said tenders will be opened at 10 a.m. September 14, 1954, in the No. 1 Committee Room, City Hall, Vancouver, B. C.

The lowest or any tender not necessarily accepted.

RONALD THOMPSON,
CITY CLERK.

City Hall,
Vancouver, British Columbia,
Canada,
July 13th, 1954.

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